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SCHOOL SCIENCE AND MATHEMATICS

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AN ENGLISH IMPRESSION OF AMERICAN GENERAL SCIENCE

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As the Bush Research Fellow in Education I was enabled to spend some five months of last year in the United States studying the problem of the teaching of General Science. During that time I travelled extensively. Thanks to the never failing courtesy and hospitality of educational superintendents and administrators I was able to spend from two days to two weeks in each of 23 cities and districts in thirteen States from the East Coast to the West. In all I sat through General Science lessons in over 120 Junior High Schools, in addition to visiting 12 Universities and 8 Teachers Colleges. With not more than one or two notable exceptions I talked with all the recognized authorities in the field of General Science. My object in visiting so many school lessons in General Science was to see exactly what was being done in practice in the matter of teaching General Science, and the response of both teacher and taught to this subject. I found that from the Teachers Colleges and Universities—notably of course, Teachers College, Columbia University—I could ascertain the theories and hopes for the subject, but that the only way to get an idea of what was being done was to visit the schools themselves in as many different States as possible, and of as widely varying types as possible, from the congested urban school to the remote country district. I mention these facts in order to justify my compliance with your Editor's request for an article on "My Impressions of General Science in America."

Within the limits of an article these impressions must be condensed, and the opinions dogmatic; a full report is in preparation.

My first impressions were of the educational system of America as a whole, the framework within which General Science functions as part of the curriculum. I was impressed—this is the appropriate word—by the national belief in education, as particularly evidenced by the money lavishly spent on high schools and their equipment, and the free provision of such education. The task of giving all children a secondary education is formidable, but one felt sometimes that the children were getting not only as much school education as they could assimilate, but often more, to their own detriment; in other words that it is a mistaken assumption that all children can profit by prolonged school education, however varied. Moreover the same enthusiasm for education which is demonstrated in the provision of splendid buildings and lavish equipment does not extend to consideration for the teaching staff. Inadequate salaries mean second-rate personnel, and insufficient training. My impression of the many teachers I came into contact with, particularly in the high schools, with several honorable exceptions, on the whole was not favorable. Lack of training, lack of academic background, lack of the vivid personalities lost to the profession by inadequate salaries, cannot be counter-balanced by enthusiasm and devotion, both of which were evident in many cases. A profession which is regarded as a temporary stopgap by most men, and which makes it possible for a boy to go through the whole of his school life without ever having come into contact with a man teacher is not adequate for its responsibilities. Fortunately the present economic crisis which renders business opportunities less attractive and less safe is helping to remedy the shortage of men teachers; but little can be done until such salaries are paid so that it is worth while for a good man to remain a practising teacher instead of becoming an administrator. An instance of the bad effect of salary difficulties is the custom of paying less salaries in the Junior High School than in the Senior High School. Since General Science is mainly a Junior High School subject, a good teacher in this subject receiving promotion to

higher pay in a Senior School is lost to General Science, which suffers thereby. I came across several instances of this.

One other feature of the general school system is relevant to this discussion, the credit system, whereby the accumulation of credits given for passing through satisfactorily a course in a subject at any stage of the school career is necessary for graduation from the school. Not only does General Science suffer particularly from this system as it is only with difficulty that it obtains recognition as a credit subject for high school graduation, but the whole credit system emphazises the disconnectedness of the various subjects and militates against continuity within a subject. Science in the schools becomes a series of disconnected courses in the various sciences, having, under the elective system, no continuity or predetermined sequence from one science to the other. There is yet no 6 year high school plan, let alone a 12 year plan, of school science, although I found some pioneer attempts in this direction.

Under the organization which permits to the pupils choice of elective subjects, since very often the choice by the pupil is determined by the attractiveness of the subject, each elective subject is on competitive terms with the rest. The consequent desire to "sell" each elective subject has resulted in a commendable effort to emphasize the attractivness of General Science by insisting on its relatedness to the everyday life of the pupil. This has had the beneficial effect of releasing the subject from the narrow outlook of the academic special science, and enabling it to cast its net wide over the environment of the pupils. But it has also led to the tendency to regard the popularization of the subject as an end in itself, to sacrifice cultural and aesthetic values of science teaching to its utilitarian value, to reduce it from a science, with all that is implied by the scientific attitude and method, to disconnected fragments of interesting information. This tendency not only is noticeable in the classroom, but is also evidenced by the objective tests used so much in General Science which emphasize the factual content of the subject to the detriment of the non-measurable, but nevertheless as important, outcomes of the subject.

Now to come to my more specific impressions of General Science. The greatest contribution to my mind that American practice makes to the whole subject of General Science teaching is the growing emphasis on General Science as a subject complete in itself. Too often in the past in America —and I am afraid that this still holds true of English General Science—General Science has consisted of the more elementary and interesting portions of the more specialized sciences, Physics, Chemistry and Biology in particular, still retained in their watertight or rather idea-tight compartments, a heterogeneous collection of delectable titbits stolen from the various sciences, but still retaining the formalism of their original settings which places first the importance of the subject rather than that of the pupil. It would not be correct to say that this view of General Science is dead; indeed I found in some schools General Science being taught under the separate headings of nature study, heat, electricity, chemical science, sometimes even under different teachers. But the modern viewpoint that America contributes in the matter of General Science is that it is the science of the pupils' environment, that its content consists of problems carved out of the children's environment, and that the solution of these problems can be obtained by the use of the method of science, using for that solution any of the facts and principles of the several sciences as and when required. The method discards logical presentation of the subject matter of these sciences, but achieves continuity, sequence and scientific unity by interpreting the child's environment in terms of the child's interests, relating in order the What? the How? and the Why? Thus General Science ceases to be general information to whet the appetite for the specialist sciences, but synthetic science, the science of the environment, competent in every respect to rank equal with the other sciences. I do not say that this is generally held in the teaching field, but there is no doubt that it is the view which is steadily gaining ground.

Other impressions are of method. In science in England there is no method other than the individual experimentation method in the laboratory. This is probably a direct result of Armstrong's heuristic teaching which implied that

everything learned in science should be discovered by the pupil himself. So that to the demonstration method, which is rapidly superseding any other method in General Science in America as far as I could judge, my first reaction was one of antipathy. But my experiences have convinced me that the teacher demonstration or teacher-pupil-demonstration method has at any rate as much of educational value as the individual experimentation method, which more often than not becomes mere aimless business in the laboratory, with the pupil just following blindly given directions "to verify" and having no conception of the aims and principles involved. I am not concerned with the advocacy of the demonstration method on the grounds of economy; I believe that some of the reported investigations on the validity of the two methods start with the case prejudged in favor of the demonstration method because of its economy in time and money. But I do think that the demonstration method in the hands of a fairly capable teacher gives a clearer impression to the class not only of the principles involved in the solution of a problem but also of the scientific method and attitude. The technique of laboratory manipulation is not taught by this method as by individual experimentation, but that technique seems to me one of the non-essential outcomes of school science. As far as equipment for this demonstration method is concerned, I commend the excellent scheme of unit boxes of apparatus in use at Boston, particularly for teachers inexperienced in manipulation of apparatus.

I found myself continually being brought up against the difficulties of inexperienced and untrained teachers of General Science. Often I found the teachers of General Science had no qualifications for their task, save in some instances an unbounded enthusiasm for, and belief in, their new subject. At the worst they were teachers trained in, and with experience of, the teaching of a specialist science; these almost without exception retained the logical sectionized viewpoint of their specialized science which is incompatible with the broad and generous outlook on science necessary for the right conception of General Science. At best they were completely unqualified in General Science, but drafted from other subjects and often from other schools to

the Junior High School, and set to the task of General Science as the Cinderella of all subjects that no one else would teach, rather like, I confess, the teaching of Scripture in English secondary schools. In one school for instance, on enquiry I ascertained that all the teachers of General Science in a particular school had majored in mathematics; and this was not an isolated example. On the whole I would prefer General Science to be taught by such than by those who had majored in any one science. At any rate the former would have a broader standpoint.

It was to obtain some information on the training of teachers for general science that I visited a number of universities and training colleges, but my effort was fruitless. I reluctantly came to the conclusion that there is no systematic training of the teacher of General Science; nor even in most places any conception that such a problem existed. In one or two teachers colleges only, did I find any serious attempt to tackle this problem of what training should be given to the intending teacher of General Science, and then it consisted mainly of various disconnected courses of the special sciences with no attempt to co-ordinate them or to present the viewpoint of General Science. This shortage of teachers trained and qualified in General Science is a serious matter and yet one that does not seem to have commanded sufficient attention. Nevertheless I have been impressed with the energy and enthusiasm of many of the practising teachers of General Science who are obtaining their necessary knowledge of science and method in their spare time, either as members of the numerous syllabus committees, or attending courses of lectures after school or in the vacations. Much of the progress of General Science has been due to this enthusiasm, but it does not solve the fundamental problem of the training in General Science of incoming teachers.

One of the results of the existence of the many untrained and unqualified teachers of General Science is the extraordinary and widespread dominance of the textbook. Throughout my extensive tour I found at the most four or five different textbooks of General Science in use, and in over 80% of the schools the textbook was one or other of the two latest. Moreover in most cases the courses of study were

rigidly based on a particular text. There is no doubt that the textbook has been and still is the most potent influence for progress in General Science; it is fortunate that on the whole the authors have been enlightened educationists, conscious of their responsibility, and it is only fair to say that the most recent textbooks of General Science are soundly constructed and attractively arranged, and, together with the usual very detailed handbook for teachers, constitute an excellent source of General Science material and method. That's the trouble. In the hands of inexperienced teachers the excellent textbook becomes a bible, never to be deviated from by a hairsbreadth, and its contents must inevitably be true. This is an attitude which not only stereotypes and mechanicalizes the teacher, stifling any departure from the given sequence, no matter how insistent the request from the class, but in its belief in the printed word, so easily communicated to the pupils as I discovered going round classes, is the negation of the scientific attitude and method. To some extent this possibility of implanting an implicit belief in a textbook is being minimized by the increasing tendency to supply for the use of each child not one textbook but several, to furnish him, in other words, with alternative and possibly contradictory sources of information. This is a hopeful and encouraging development; for one thing it teaches the right use of books, but its value is considerably minimized if the reading, as is so often done, is set by numbered pages instead of topics. To find the references to which involves the intelligent use of the index, is part of the technique of scientific enquiry.

I found what seems to me to be a regrettable practice prevalent in most schools of expecting problems raised in the course of class discussion to be solved by private reading of the textbook. Of course a certain amount of information, even in General Science, must be acquired from books and not from experiments, but the practice of private study from textbooks again overemphasizes their importance as a source of information. Moreover it suffers from the disadvantage that does not seem to be generally recognized that such private study implies an ability to read and to understand thereby. Since the art of acquiring information by means of the printed page is by no means easy,

for what is taken from the printed page depends in large measure on what is brought to it, and as an art must be acquired, it is surprising so little attention is paid to this reading ability which is generally assumed. Only in one district did I find a recognition of this problem, and a consequent division of the children into classes on the basis of their reading ability.

The tendency towards standardization and stereotypedness in General Science, deplorable, however good the standard courses are, because General Science must stand directly related to the child's own environment which must change from locality to locality, is still further evidenced by the latest craze for workbooks. These very ingenious time and labor savers were sweeping the country last year when I was investigating. The aim of building their own textbooks appealed to the pupils as did the fascination of filling in the provided gaps and blanks, but I doubt if science is taught thereby; after all, directions which merely keep pupils seemingly busy and quiet may not be educationally worth while. There is no doubt that work books serve a useful purpose in the hands of an experienced teacher, but paradoxical as it may seem, inexperienced teachers might teach better science without them.

While on the subject of notebooks, it is relevant to note how the influence of an external examination, as in New York State, in which General Science may be a subject was to deaden and stereotype the teaching and to result in the production of specially dictated notebooks for the purposes of the examination. I was relieved for the sake of any progress in General Science in that State to learn that it was proposed to discontinue the Regents Examination in that subject. "Key" experiments that had to be done were another result of the examination pressure, common here in England, but fortunately not particularly prevalent in America, save in the Eastern States, the least progressive educationally of all.

One feature of the General Science work that struck me very favorably was the encouragement of the production of reports, both written and oral, by the children on subjects in which they were interested. I saw a number of these written reports, particularly in Los Angeles, produced

mainly in the children's spare time and was amazed at their excellence, considering the age of the Junior High School children concerned. I took some of these reports back with me, and under their inspiration, similar work has been started in my own school and I hope to effect an exchange with the Los Angeles children. I was impressed, too, by the oral reports, often accompanied by demonstrations. These were notable features of the science clubs I visited. Individual investigation of real problems of interest, either from books or experiments, the latter preferably, by the children themselves because they want to, and the reporting to the class of the results obtained form an excellent training in the attitude and method of science.

The additional aids for teaching General Science impressed the visitor. Some of them, like many class room legends, posters and charts of absorbing interest were obviously inspired by the desire to "sell" the subject, but nevertheless served a useful purpose in stimulating and maintaining interest. Others, like the film, many excellent examples of which I was able to see in use in the classroom, left much to be desired in the matter of intelligent handling. They can never be an effective substitute for the personality of the teacher, but form a useful supplement. That is why, I think, the film, which so easily can be satisfied with passive attention and which because of mechanical difficulties is not able to be stopped at any point to give, for purposes of comment, a still picture of sufficient illumination, is best replaced by the newer development of the still film, consisting of a number of isolated pictures, like lantern slides, mounted on the same film which can be screwed round. These pictures remain disconnected and require the effective commentary and discussion of the teacher to form a connected series. The generosity of industrial firms in providing free specimens and pamphlets is notable and shows an enterprising spirit of advertisement, not without an educational value.

One of the general disappointments of the content of General Science in America is the almost universal omission of biology and the concentration on the physical aspect of the environment. The human and living side of the child's surroundings surely require as much attention as the

physical and purely material. This is especially the case with the child's immediate biological environment—his body. The teaching of hygiene seems sadly neglected. Moreover it is obvious that important biological principles are at work in our civilization, and the justification for including such teaching in General Science is not only that it is an important part of the environment, but since it still happens that the only science some children will get in school is General Science, such vital information should be there. I found certain attempts to remedy this by insisting on a sequence of General Science and Biology, and also by including the Biology as an integral part of the General Science course. Textbooks embodying these principles are apparently in preparation.

I have ranged over a number of topics, with the intention of being critical. I have purposely omitted any reference to the numerous "plans" of teaching that I encountered everywhere. Although some of these undoubtedly contain some valuable features, the general impression is that they are all ineffective substitutes for experienced teachers, as is evidenced by the almost hysterical adoption of these plans and their subsequent and not delayed relegation to oblivion. The supply of teachers effectively trained in the content and method of General Science is the crux of the whole problem of teaching General Science in America, and the solution of this problem will automatically solve most of the others that I have raised.

Whilst being intentionally critical, I must record the fact that I believe there are many things of promise in the General Science teaching in America, things that we in England have yet to learn. The fact that General Science teaching in America is much older than in England enables English observers like myself to view as it were in retrospect the future course of General Science teaching here in England, and by honest criticism endeavor to short-circuit some of the mistakes that have been made. I would like to pay tribute to the pioneering spirit of the adventurous advocates of General Science, who have faced seemingly overwhelming difficulties with a courageous belief in their subject, and now have the deep satisfaction of seeing it established on such a plane that it fears competition with no

other school subject and that with all its imperfections, which they are the first to acknowledge, it can provide valuable inspiration to countries other than that of its origin. I should like, too, to take this opportunity of thanking my many American friends for many courtesies and assistance in this investigation. To name them all—some 160—is impossible, but I must acknowledge my chief indebtedness to Professor S. R. Powers, an outstanding name in General Science.

EXPERIMENTS IN ALLOTROPY. I. ARSENIC AND IRON ALLOTROPES

By Eugene W. Blank,
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Introduction

When an element exists in more than one form, in the same physical state, whether gaseous, liquid or solid, the forms are termed allotropic modifications. The less common forms are usually regarded as "allotropes" of the more well known form. The term allotropy includes modifications differing in chemical behavior, such as oxygen and ozone, and those forms differing in physical properties, as the various and numerous modifications of carbon and sulphur.*

Usually there is a difference in molecular weight between two allotropic forms. In other cases there is evidence for believing the various allotropic forms possess different atomic structures. Allotropes of the same element invariably differ in energy content. The formation of ozone from oxygen is endothermal. Similar statements hold for the different forms of phosphorus, sulphur and carbon.

Arsenic

Arsenic exists in three well known forms. The common or "metallic arsenic" occurs in steel-grey, rhombohedral crystals with a metallic luster. It is brittle and conducts heat and electricity readily. In general physical properties grey arsenic resembles the metals but its chemical behavior stamps it as a non-metal. It is called grey or γ-arsenic to distinguish it from two other allotropes.

*Only such elements as are the basis of experiments will be discussed in this series of papers.

A yellow variety, designated as α-arsenic or yellow arsenic can be prepared by distilling arsenic in a current of carbon dioxide and suddenly chilling the vapor by means of a mixture of ether and dry ice.

For the preparation of α-arsenic arrange the apparatus shown in Figure (I). Grey arsenic is placed in a Pyrex tube bent to the approximate shape shown in the diagram. Cooling is accomplished by a mixture of ether and dry ice or by the latter alone. A fifth of a gram of arsenic is sufficient for the experiment. Pass a very slow stream of carbon dioxide through the tube and heat the arsenic by means of a burner.

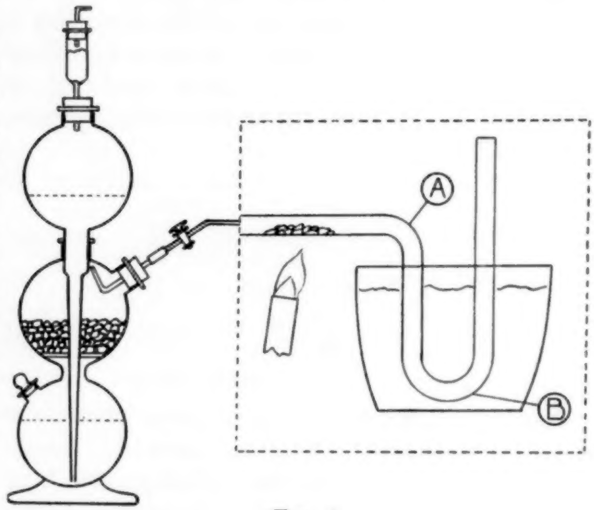

FIG. 1
Preparing arsenic allotropes. An enlarged view of the apparatus is shown within the dotted lines. Black arsenic collects at (A) and a yellow modification at (B).

The arsenic sublimes slowly at 100° C. and more rapidly at higher temperatures giving a lemon-yellow vapor that condenses in the cooled portion of the tube. Just beyond the heated grey arsenic some of the vapor condenses to a black, glossy mass. This is the third modification of arsenic, called β-arsenic or black arsenic. The yellow arsenic obtained in the experiment quickly changes into the grey variety when exposed to light. At 360° C. the black modification is converted into the grey variety.

IRON

If the cooling temperatures of a molten mass of pure iron be plotted against time it will be found that the cooling process is not uniform and continuous but that at various temperatures there are fluctuations due to the transition of the iron from one allotropic modification to another. Iron exists

in three crystalline modifications known as α-ferrite, γ-ferrite and δ-ferrite. Each of these forms is definitely bounded by a transition temperature. It is impracticable to demonstrate these transition temperatures experimentally but if the cooling iron contains some carbon the above transition points tend to approach 720° C. At the latter temperature there is an abundant evolution of heat sufficient to make the cooling iron glow more brightly than before the point is reached. This phenomenon, first observed by Barrett in 1874, is commonly known as recalescence.

To show the recalescence of a steel wire arrange the apparatus shown in Figure (2). The pointer is attached to the suspended iron wire by looping the latter around it several times. The end of the pointer rests in a shallow hole bored in the ringstand rod. The ends of the wire are connected to a suitable source of current through a resistance. On completing the electrical circuit the wire expands and the indicator changes position. When the circuit is broken the wire cools and slowly contracts, lifting the pointer attached to the wire. At the recalescence temperature the pointer suddenly becomes motionless and then reverses its direction of movement as the wire is momentarily lengthened due to the evolution of heat.

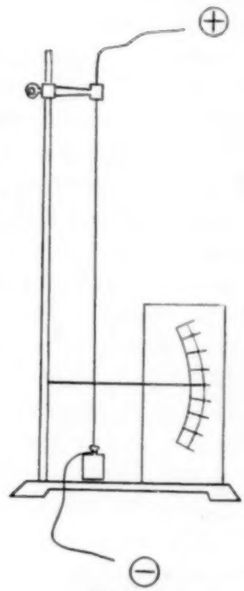

FIG. 2
Arrangement of apparatus to show the recalescence of a steel wire.

LITERATURE CONSULTED

(1) MELLOR, "Modern Inorganic Chemistry," Longmans, Green and Co., New York City, 1922.

(2) SENTER, "Text-Book of Inorganic Chemistry," Methuen and Co., London, 1916.

I consider knowledge to be the soul of a Republic, and as the weak and the wicked are generally in alliance, as much care should be taken to diminish the former as of the latter. Education is the way to do this, and nothing should be left undone to afford all ranks of people the means of obtaining a proper degree of it. . . .—John Jay.

THE SELF-TRAINING OF A TEACHER*

By Charles S. Slichter,

Dean, Graduate School, Professor of Applied Mathematics, University of Wisconsin

Forty-five years ago this very day—almost this very hour—I began at Wisconsin my university teaching. I cannot think of anyone less prepared in technical psychology and pedagogy for such a position. Experimental psychology was just then beginning, and the science of education was groping about like a small child. Perhaps, therefore, I should also say that I know of no one who at that date was better prepared in technical pedagogy for university instruction. I started off with four daily classes of forty freshmen each and an advanced class of two students soon dwindling to one. The universities of America have always been generous, even over-generous, in supplying an abundance of students to their green and utterly inexperienced tutors. I was so unsophisticated that I could not think of a finer job on earth than teaching mathematics to freshmen. I thought, until quite recently, that everybody was of the same opinion. It was a shock to me to learn that some think that there is a higher job. But I really did not teach freshmen. I taught attorneys, bankers, big business men, physicians, surgeons, judges, congressmen, governors, writers, editors, poets, inventors, great engineers, corporation presidents, railroad presidents, scientists, professors, deans, regents, and university presidents. That is what my freshmen are now, and of course they were the same persons then. I was teaching with such enthusiasm and was so proud of my classes that it never occurred to me that my work could be criticised. It was the self-confidence and conceit of a beginner. But President Bascom visited my classes. After each visit I was called to his office. He went over things with me, criticizing at length, but justly and with uncanny precision and directness, calling upon his imagination to say something pleasant at the end. Why did President Bascom take such trouble with an insignificant tutor? It was because he knew that I was not teaching freshmen, but the real men I have listed. That is the first lesson that the university

*An address before the Mathematics Session of the Summer School for Engineering Teachers, University of Minnesota, Sept. 5, 1931. Reprinted by permission of the *Journal of Engineering Education*.

teacher must learn. Our contact with students must not be at a moment nor at a point, but through the complete trend of a life, the years to come being of one substance with the present. We must be ready by our magic to roll the long scroll of a life before us to the epoch of the present or to the epoch of the future, as we will. A prophet once exclaimed: "Behold the dawn! Behold the dawn! The things as yet but half declared command the coming day."

The second lesson for the young teacher lies in his need to become an artist in handling human material. He should know what is going on deep in the brain of each of his students. This may not appear in the manuals of pedagogy, but nevertheless this difficult duty belongs to us. In those wonderful years following adolescence, when the pulse is steadying to a firmer beat, then youth seems to cover himself with a cloak of diffidence and timidity. The new man is imminent but hidden from view. He will hardly confess to his own father the plans, the ambitions, the dreams of service that lie deep in his conscience. To the superficial teacher he seems a trifler, but that is only the garb he assumes to hide his first aspirations to man's estate. Few young men are really triflers. Way back deep in the head of nearly every youth is the ambition and the determination to make something fine out of his life. Let the teacher discover his way to this hidden place and build his influence upon it. The teacher must train himself to be an artist in human material.

The third lesson for the college teacher is to learn the art of making his subject interesting. It is not the task of the teacher to teach interesting things, as the quacks proclaim. The job is to make interesting the things that must be taught. He must teach the basal sciences as they exist and it is the task of the teacher to make the things therein contained part of a living world full of the adventure and the hazards of learning. This, of course, is the reason why an instructor must be highly trained and productive in his special field and widely read in the history of science and also not ignorant of the literature of the race.

This last point deserves further elaboration, especially for the younger instructors. A sad experience in visiting a classroom is to discover many rich personalities on the stu-

dent side of the rostrum but a weak or undeveloped personality on the teacher side of the rostrum. It is obvious in such a case that the teacher will find great difficulty in overcoming this potential difference. How may the teacher develop a rich personality? Unfortunately there are no psychological calisthenics that can train a weak into a rich personality. It is largely a matter of inheritance; luckily, however, it is not a matter of family but of racial inheritance. We are all mentioned in the wills of Homer and of Shakespeare and of all the great masters of letters; we do not share merely in part, but each of us inherits in full all of their rich chattels. You may be assured that great literature, great history, and great biography belong to us—even to mathematicians—and may be claimed and cultivated as our own. Hence the students have a right to find something more in the classroom than the narrow mechanics of a scientific machine. Instead of twenty times at the movies, better the guest of Homer twenty times. What has Homer to do, you will ask, with the teaching of mathematics? I use Homer, of course, merely as an example. His heavy-breasted heroes contending in the sweat of their primal passions are reacting to emotions that sway men everywhere and to motives that rule our own destiny. In the story of their strife the fibres of your being will vibrate with the ambitions and angers universal to humanity; your personality will quicken to a new appreciation of the facts of life. In other words, the ingredients necessary to compound a man can hardly be omitted from the recipe for making a teacher. You need not be afraid, therefore, to enrich your life by the cultivation of letters and by indulgence at the feast of the humanities.

If it were not for the demand of interest, perhaps we could standardize our work by questionnaires and turn the classroom over to the radio or the phonograph. Especially important is the history of your own specialty. The student needs to know the source of some of the great discoveries and the form and texture of their primitive formulation. Let him learn that one of the earliest physicists and hydraulic engineers was a barber of Alexandria of 2,000 years ago. From the money saved from shaves and haircuts he built the first valve pump and the first fire engine. If the student will inspect a village fire pump today, he will find the same curious curves to the hand brakes and to the air cham-

ber adopted by Ctesibius twenty centuries ago. He will note in the history of technology the same useless ornamental scrolls on the handle of a hand saw that were used in Egypt 5,000 years ago. The student may forget formulas, but he will not forget the story of Archimedes running through the streets of Syracuse naked from the baths, shouting "Eureka! Eureka!" The reason is that these are human interest stories. Science is news, and at one time some of the items we teach should have been first page write-ups. Archimedes with his Eureka incident should have commanded a first page "banner spread." Human interest comes first, but a second claim for the introduction of the history of science is to demonstrate that knowledge is a growing organism linked intimately with the expansion of human progress. Each age seems to have an outstanding problem to serve as a challenge to its scholars. This is the age of the Michelson-Morley experiment. The challenge of this paradox has produced more good electro-dynamics and more good mathematics than thousands of successful investigations. The Michelson-Morley dilemmas of the early Greek geometors were the squaring of the circle and the tri-section of an angle. These problems brought forth more good geometry than all the solvable problems of the day. The Michelson-Morley dilemma of the seventeenth and eighteenth centuries was the problem of the complex course and irregular motions of the moon, and for more than a century it was the challenge that brought to the contest the great men of those days—Newton, Clairaut, MacClaurin, D'Alembert, Euler, Lagrange, La Place. These giants were developed in their strength by the problem of the moon. Mathematics is the story of great deeds. Its history cannot be ignored if we would face our students with enthusiasm and virility.

But mathematics has a present and a future as well as a past. Its contacts with the other sciences and its application to some of their major problems must not be unknown to the teacher. He will find ample opportunity to add interest to his instruction by limited use of such erudition. Students are interested in the power as well as in the romance of the giant we call mathematics.

Fourthly, the instructor must maintain a creative contact with research in some field of learning. This observation is so trite and commonplace that I am ashamed to make it.

But I mean more by it than is commonly intended in such discussions. It is the creative attitude towards all phases of life, not merely to a specialty, that I would emphasize. I learned this lesson from President Bascom years ago at college rhetoricals. The theme of his discourse was the three attitudes of the individual toward the universe: first, the cognitive attitude founded upon the desire to know; second, the aesthetic attitude, founded upon the desire to recognize and appreciate the full beauty of existence; third, the ethical attitude, founded upon the desire to achieve the highest good. I do not believe that there was anything new in that topic—very likely the theme goes back to Aristotle; but the novelty lay in what followed, for then came John Bascom's powerful exposition of the duties of life that each attitude implies. It was the duty of everybody, not the duty of specialists, to add year by year to the store of human knowledge; it was the duty of everybody, not the duty of poets and artists, to contribute day by day to the beauty of the world; it was the duty of everybody, not the duty of a few leaders of men, to make hour by hour the world a better place. The virility and power with which all this came forth, I, of course, cannot picture nor describe. It was the radiation from a prophet. It entered my frame and put there a tenseness that has never vanished—it changed in an instant the dynamics of my life.

I learned that day that we are not only teachers of mathematics, but philosophers of the good life. The duties press upon us to enrich and refine all contacts with the world and to hand on the spirit of it to our students.

The teacher cannot accomplish everything. Perhaps it is more in his power to enrich the personality of the student than it is to develop his mentality. The teacher can train the student in the facts of his subject; he can drill into him the technical skill required; he can develop in him a proper attitude toward learning; and, most of all, he can train him in proper habits of work and of self-expression. But the teacher soon comes up against a stone wall. The God-given abilities of the student, the inborn qualities necessary to success, the teacher can neither create nor augment. Education wins many victories but there are vast domains it cannot penetrate. The supreme triumph of the educational process is shown by the case of Helen Keller. All the train-

ing that a teacher can give is there illustrated by an example that everyone can understand. But the God-given abilities were present in Miss Keller at the beginning and antedated the work of the teacher—those were gifts that were not transferable and that the teacher did not create. Our freedom and the freedom of the student is harshly limited by nature. We are forced and propelled by many engines within us over which we can exert but slight control. We are propelled by our inheritance—by the powerful engine of heredity. We are propelled by our emotions—fear, vanity, and so on, and by all the range of animal passions and appetites. We are propelled by the forces of habit—"our past actions press mightily upon us for repetition." But here lies the golden opportunity of the teacher. He has marvelous power to develop the formative forces of habit before the years have made it too late. Mathematics here holds a central position and its classrooms are the best laboratories for the development of intellectual and scholarly habits. We teachers of mathematics recognize and gladly accept these responsibilities.

In bringing this brief discourse to a close, I well know that I have not said what you expected me to say, nor what you wished me to say. You desired, I am aware, a discussion of direct concrete items of technique. You wished to know of standardized procedures, supported by questionnaires and comparative tests. I have deliberately and knowingly seen fit to disappoint you. I have done this because I feel the need at the present moment of shifting the emphasis to the temper and the spirit of our duties, rather than to their technique. Teaching is more than an art to be practiced—it is a life to be lived. At the present moment it is important to stress the activities that are attractive to the gifted teacher. There is today urgent need to insist upon a teaching staff of virility and catholic personal qualities. We must have help at this point from the faculties and from all the university authorities and from the public. The greatest obstacle to the attraction of gifted men and women to the teaching profession, and the greatest discouragement to their continued enthusiasm and success, is the wide open admission to the freshman class of incompetents and the mentally dull. Certain inborn abilities must be brought to college by the student himself—the university can neither

create nor augment them. Some selection, some rejection, much encouragement to the gifted student (whether rich or poor) is a St. Peter's job at the college gate. Stanford University, California Institute of Technology, and a few others have shown the way. Unless we can restrict college admissions to those who possess a minimum of inborn abilities, no amount of pedagogy and no amount of instructional skill and no amount of enthusiasm and self-training can prevail. A beginning in the selective admission of students is being made—it should be hastened and the support of the public should be forthcoming. Other things seem favorable; the competition for positions is becoming keener, the salaries are slowly moving to a higher level, and the qualifications for the Doctor's degree tend to become more exacting. It has seemed well, therefore, for me to emphasize the higher qualities the teacher should develop by careful self-training and whole hearted devotion to his students. He can be assured that there is no vocation where there are so many good things to do and that leads so readily to contentment and the sense of victory. Although by temperament and other qualities I was ill adapted to the life of a teacher, I wish to testify after all these years that it is indeed the good life we attain—I am sustained and confirmed by its many rich rewards.

OCEAN TO SWALLOW BIG CITIES OF WORLD

New York is destined to become an American Venice. Her streets, canyoned by skyscrapers, will be filled with water to the twelfth floor.

This is the fate of the world's largest city and of all lowland cities, pictured by Dr. W. J. Humphreys of the U. S. Weather Bureau before the American Meteorological Society.

The filling of Wall street with water will follow the melting of the great ice caps of the earth to raise the ocean level about 150 feet, Dr. Humphreys said. We do not expect this tomorrow, he qualified, but it is on the way. And the more the earth's permanent ice melts, the faster that which is left turns into water.

Explorations of the past year which determined by sonic sounding the average thickness of the great Greenland ice sheet to be about one mile, make possible a fairly accurate estimate of the height the oceans will rise, it was pointed out. Little has been known in the past about the quantity of ice on the earth.

Dr. Humphreys said there must be 4,000,000 cubic miles of ice on Greenland, the Antarctic continent and Iceland. The earth is slowly getting warmer and eventually all will melt, scientists generally conceded.—Science Service.

OVERLAPPING OF CONTENT IN TEXTBOOKS IN GENERAL SCIENCE AND BIOLOGY

By William A. Rodean,

Chisholm Junior High School, Chisholm, Minn.

One of the problems confronting the curriculum makers in science today is that of organizing the science material in the various courses so that there will be a definite sequence from unit to unit and from year to year—a sequence that will increase in difficulty commensurately with the pupil's increasing capacity. Since general science and biology are quite generally offered as high school subjects, it should prove valuable to determine how these courses articulate. This is a second article summarizing a study on the overlapping of the content in textbooks in general science and biology.[1]

Method of Procedure

This study is based on an analysis of five general science textbooks and four textbooks in general biology. The material in each book was classified under the sciences: biology, physics, chemistry, physiography, astronomy, and miscellaneous. The material under each science was then further classified and sub-classified into smaller units.

The comparative treatment of each item of overlapping material in general science and biology texts was studied, first, by comparing the space devoted to each topic and subtopic in each general science textbook with the space given to the same topics and sub-topics in the average textbook in biology; and, then, by comparing the space devoted to each topic and sub-topic in each textbook in biology with the space given to corresponding topics and subtopics in the average general science text. From the data obtained, the space given to each topic and sub-topic in the average general science text was compared with the space given to the same topic and sub-topic in the average biology text.

To show possible differences in the actual overlapping material, each topic and sub-topic in each textbook in general science was carefully analyzed and compared with

[1]The first article of this study was published in the *School Review*, March, 1932, and includes a more detailed description of the method of procedure.

corresponding material in each textbook in biology. In a similar way, each textbook in biology was carefully analyzed and compared with corresponding material in each textbook in general science.

Material in Textbooks in General Science Overlapping Material in Textbooks in Biology

The average textbook in general science contains 17.8 per cent of material in the fields of physiography, astronomy, and miscellaneous that does not overlap textbooks in biology. According to Table I, 9.8 per cent of the average textbook in general science is given to chemistry. This is 3.21 times as much as is given to chemistry in the average textbook in biology. The remaining content consists of 38.3 per cent of physics and 34.1 per cent of biology.

Table I—Average Amounts of Space Given the Various Sciences in Textbooks in General Science and Ratio to Average Amounts of Space Given Same Sciences in Textbooks in General Biology.

Classification	Average number of lines	Average Percentage of space	Ratio to Space Given Same Subject in General Science
Chemistry	1238	9.8	3.21
Physics	4905	38.3	66.28
Biology	4368	34.1	.35
Physiography	1305	9.7	None in General Science Texts
Astronomy	649	4.8	
Miscellaneous	408	3.3	
Total	12873	100.0	

A comparison of the treatment given each of the sciences in the average textbook in general science and the average book in biology is given in Table II. The table reads as follows: Of the total amount of material devoted to chemistry in the average textbook in general science, 72.2 per cent is given no treatment in the average textbook in biology; 19.9 per cent of the material is given a brief and general treatment in the average textbook in biology and the remaining 7.9 per cent of chemistry material in the average textbook in general science is given approximately identical treatment in the average textbook in biology. Of the physics ma-

TABLE II—COMPARISON OF TREATMENT OF CONTENT IN THE AVERAGE TEXT BOOK IN GENERAL SCIENCE WITH TREATMENT GIVEN IN THE AVERAGE TEXTBOOK IN BIOLOGY.

Treatment in books in Biology	Chemistry	Physics	Biology	Other Sciences	All Sciences
None	72.2	95.2	2.0	100.	62.1
Brief and general treatment	19.9	4.8	21.0	0.	11.0
Approximately identical treatment	7.9	0.0	62.0	0.	21.7
More complete of technical treatment	0.0	0.0	15.0	0.	5.2
Total	100.0	100.0	100.0	100.	100.0

terial in the average textbook in general science, 95.2 per cent of this is given no treatment in the average textbook in biology and the remaining 4.8 per cent is given a brief and general treatment in the average textbook in biology. The average textbook in general science contains 34.1 per cent of biology. Of this material, 62 per cent is given approximately identical treatment in the average biology text; 21 per cent is given less completely in the average text in biology; 15 per cent is given a more complete or technical treatment in the overlapping texts; and only 2 per cent of the biology material

TABLE III—AVERAGE AMOUNTS OF SPACE IN TEXTBOOKS IN GENERAL SCIENCE GIVEN TO VARIOUS BIOLOGY TOPICS AND RATIO TO AVERAGE AMOUNTS OF SPACE GIVEN SAME TOPICS IN TEXTBOOKS IN BIOLOGY

Topic	Average Number of lines	Average Percentage of Space	Ratio of Space Given Same Topic in General Science
Human Biology			
Physiology-Hygiene	746	17.1	0.35
Health and Disease	614	14.0	0.43
Ventilation and Humidity	140	3.3	1.63
Water Supply and Sewage Disposal	272	6.2	3.83
Foods	581	13.3	0.75
Narcotics and Stimulants	86	2.0	0.33
Heredity and Eugenics	38	.9	0.14
All human biology	2477	56.8	0.49
Plant Biology	1254	28.7	0.45
Animal Biology	246	5.6	0.08
Miscellaneous Biology	391	8.9	0.28
Total	4368	100.0	0.35

in the average general science text is given no treatment in the average textbook in biology.

A study of Tables III and IV shows that biology receiving major emphasis in textbooks in general science includes the study of water supply and sewage disposal and ventilation. Biology receiving nearly identical treatment in overlapping texts consists of foods and some phases of first aid and physiology hygiene. The study of plants and animals receives major consideration in textbooks in biology.

TABLE IV—COMPARISON OF TREATMENT GIVEN BIOLOGY TOPICS IN AVERAGE TEXTBOOK IN GENERAL SCIENCE WITH TREATMENT GIVEN IN AVERAGE TEXTBOOK IN BIOLOGY

Topic	Percentage of Material Receiving Treatment in General Science				
	No Treatment	Brief and General Treatment	Approximately Identical Treatment	More Complete or Technical Treatment	Total
Human biology					
Physiology and hygiene	0.0	5.7	68.7	25.6	100.
Health and disease	0.0	4.5	67.9	27.6	100.
Ventilation and humidity	0.0	59.0	36.7	4.3	100.
Water supply and sewage disposal	10.0	81.9	8.1	0.0	100.
Foods	2.6	16.0	76.4	5.0	100.
Narcotics and stimulants	0.0	4.7	80.2	15.1	100.
Heredity and eugenics	0.0	5.8	61.6	32.6	100.
All human biology	1.8	19.2	61.8	17.2	100.
Plant biology	4.6	27.5	59.7	8.2	100.
Animal biology	1.0	2.0	55.0	42.0	100.
Miscellaneous biology	0.0	27.0	59.0	14.0	100.
Total	22.0	21.0	62.0	15.0	100.

JUSTIFICATIONS OF OVERLAPPING

The fact that over thirty-seven per cent of the textual material in general science is repeated in biology and that fifty-six per cent of the material in biology was given in general science does not necessarily mean a total or even partial waste of time and effort through duplication. The danger lies in haphazard unplanned repetition.[2] Downing says, ". . . it is evident that we need to

[2]L. H. Harap and E. C. Persing. "Present Objectives in General Science," *Science Education*, 14:482-483, March, 1930.

concentrate on a few fundamentals, to teach these thoroughly, and to pay less attention to multiplicity of detail."[3] This suggests the desirability of repeating, expanding, and further applying principles given in the earlier course so as to come nearer the goal of mastery. On the other hand, repetition might have a depressing effect as is indicated in the following quotation: "A high school student frequently believes that he has already learned chemistry, and when in college may start slighting his work, especially if the college gives him much repetition of his high school work."[4]

The writer believes that there are at least two justifications for overlapping; first, as a desirable means of reviewing worth-while principles and facts; second, as a means of preparing the pupil for more advanced science courses.[5]

The repetition of subject matter for the sole purpose of review should not be an identical treatment but should be confined to a resurvey of the important elements and should be reorganized around a smaller number of main heads or problems to permit the pupil to see the topic in perspective.

There are at least four ways in which material taught in a given course might help pupils understand similar material taught in a following course. First, the course should provide the pupil with fruitful knowledge that will establish a useful apperceptive mass; second, it should develop in the pupil desirable attitudes, ideals, interests, and appreciations that would stimulate him to seek further scientific knowledge; third, the course should be so organized and taught that pupils, having taken the course, will have grown in their capacity to do independent scientific thinking; and, fourth, some provision should possibly be provided whereby pupils will have an opportunity to develop some of the manipulatory skills needed in the more advanced science courses.

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[3] E. R. Downing, "Comparison of Lecture Demonstration and Laboratory Methods of Instruction in Science," *School Review*, 33:687-697.

[4] E. H. Westland, "How to get a Closer Relationship between the Chemistry of the High School and College," SCHOOL SCIENCE AND MATHEMATICS, 21:44-49, January, 1926.

[5] H. R. Douglass, *Modern Methods in High School Teaching*. Houghton Mifflin Co., 1926, p. 63.

SIGNIFICANCE OF OVERLAPPING MATERIAL IN TEXTBOOKS IN GENERAL SCIENCE

The significance of overlapping naturally depends on the way in which this material is treated in the given text and in the overlapping text. The overlapping material in general science textbooks is therefore classified on the basis of the extent to which similar material is treated in textbooks of biology.

Material given no treatment in biology: The average general science text contains seventeen and eight-tenths per cent of material in the fields of physiography, astronomy, and miscellaneous that does not overlap biology. An analysis of physics and chemistry texts made by the writer shows, further, that this material is not repeated nor continued in these sciences. It is, therefore, fair to conclude that a pupil, after having had a brief introduction in general science to astronomy, physiography, geology, and certain miscellaneous sciences, will have no opportunity to review and continue the study of any of these fields in any of the advanced secondary school sciences. Furthermore, since courses in physiography, geology, and astronomy are taken by a very small percentage of our college students, it can be said that nearly all of our general science students will receive no further organized study in astronomy, geology, and physiography. One is led to wonder whether we are justified in giving pupils a brief exploratory introduction to the wonders of the earth and sky and then fail to give them any opportunity to continue this interesting study in some more advanced science course. Possibly further work in any of these fields would fail to meet the objectives of secondary education as completely as the science material we are now offering high school students. On the other hand, it is probable that a thorough analysis of science needs would indicate that much of this material has far greater ultimate value than much of that now offered to high school students.

Material given a minor treatment in biology: Eleven per cent of the average general science textbook consists of material that is repeated in biology texts with a less thorough emphasis than was given in general science.

The study of water supply and sewage disposal comes under this category. This topic receives over three times as much space in general science texts as is given the same topic in biology. It is very probable that the material given on this topic in biology texts is an application of the pupil's past experience to the new biology situation, and as such, might be considered as a very valuable type of review.

Material receiving major treatment in biology: Over five per cent of the material in the average general science text is of a type that is given a more thorough consideration in the more advanced biology course. Illustrations of material of this type are: the study of osmosis, photosynthesis, and the nervous system. This presentation in general science texts might be used as a means of preparing the pupil for further scientific training along the same line in the later biology course. For instance, the brief and incomplete presentation of the nervous system in the average general science text should give the biology student a necessary and useful apperceptive mass when he faces the new problems of neurons, nerve centers, reflexes, and the more complex problems of the nervous system. The overlapping material in this classification in general science texts can therefore be justified only when the presentation is of such a type that it will actually give the pupil the desirable apperceptive mass, and will develop in the pupil those attitudes, ideals, interests and appreciations that are needed in the more advanced biology course.

Material receiving identical treatment in overlapping courses: The average general science text contains over twenty-one per cent of overlapping material that receives approximately identical treatment in the overlapping texts. Such a degree of similarity of material in general science and biology texts can hardly be justified as a desirable and efficient type of review. Such a method of reteaching does not apply the principles of good review expressed by Douglass as follows: "A review . . . should not contemplate a resurvey of all that has been covered in detail, but should select a few points on which the pupils are suspected of being weak, as well as those points which are considered of outstanding importance

for permanent retention, or as a preparation for work to come."[9]

A re-teaching of material identical with that taught in a preceding course will have little or no value in preparing the pupil for more involved thinking because it is generally conceded that exact duplication of school work usually has a stifling, deadening effect on the attitudes, ideals, interests, and appreciations of the child. Either the material in textbooks of general science should be re-organized to articulate properly with the later biology course or the biology content should be adjusted to what is being given in general science. The determining of whether a given mass of facts should be given major emphasis in general science or biology courses should be based, so far as possible, on a scientific analysis of (a) social and individual needs, and (b) the capacities of the pupils.

A given item may have very great social and individual value and should therefore be given in the ninth grade so as to reach pupils that leave school immediately after completing the junior high school. This material may be within the grasp of junior high school pupils and therefore should be given major emphasis in the course in general science. It might be found by careful analysis, however, that the inclusion of this content in the general science course would necessarily eliminate other content of great social and individual value that could not be presented in either the biology course or any later course because of its nature. The question needing solution would then be: Which is of greater value to the individual pupils, the inclusion of the given material in the ninth grade but the permanent elimination of some other worth-while science material, or the postponing of the given material to the tenth grade with the opportunity of including in the ninth grade non-related material which would otherwise have to be eliminated?

Implication: In addition to the direct conclusions from the evidence, the following implication might be justifiable: Since general science is the only course in our

[9]H. R. Douglass, Op. cit., p. 24.

secondary schools that contains a unified study of all the sciences, including astronomy, physiography, and other material not given in any high school course; since much of this content has possibly greater social and individual values than some of the material now offered in biology, physics, and chemistry; and since a year course in biology is usually offered and often required of all students; it is the writer's opinion that all of the biology material that is now given equal emphasis in overlapping texts, and some of the material that receives major emphasis in general science texts should be considered essentially as part of the second year course in general biology, and should therefore be eliminated from the general science course.

It is understood that this recommendation assumes the continuation of the present content and organization of the advanced courses in science and would possibly not hold if all the science courses were re-organized.

Recommendations: To develop a science curriculum that has dependent continuity and that increases in difficulty commensurately with the pupil's increasing capacity, it is very desirable to know how the various courses in science overlap. Further research is needed to determine how nature study or science in the elementary school articulates with the science in high school, how the various high school sciences articulate, and how the science in high school relates itself to the science taught in junior college.

MATHEMATICIANS TO MEET AT SYRACUSE

Section A of the A. A. A. S. will meet Tuesday morning and afternoon, June 21. The speakers and their subjects will be as follows:

10:00 A. M. Professor H. M. Gehman (University of Buffalo) will speak on "Homeomorphic Geometry of the Projective Plane."

11:15 A. M. Professor W. A. Hurwitz (Cornell University) will speak on "Logical Foundations for Groups and Fields."

2:00 P. M. Professor J. Shohat (University of Pennsylvania) will speak on the subject, "On Interpolation."

The Mathematicians attending this meeting will have lunch together; also after the afternoon session, there will be a picnic at a nearby lake.

We hope you can come to this meeting. The month of June is beautiful around Syracuse. Alan D. Campbell.

AN EXPERIMENT IN TEACHING SOLID GEOMETRY

By R. H. Shanks,
Culver Military Academy, Culver, Ind.

There is being conducted at Culver Military Academy at the present time a number of experiments along the line of "Individualization of Instruction." It is the good fortune of the writer to be conducting one of these classes in Solid Geometry.* The purpose of this paper is to describe briefly the nature of the experiment, the classroom procedure, and to report the results of the first series of tests.

The subject matter is limited to the minimum requirement as prescribed by the College Entrance Board. The basic idea of the experiment is to teach pupils how to solve problems in solid Geometry as a generalization of Plane Geometry. Since all pupils do not work at the same rate or in the same manner the theory of the new method is to give pupils an opportunity for individual adjustment. Under this system he may work at his own rate and find that method which is best suited for his own individual needs. He not only acquires a knowledge of space figures and their properties, but, what is eminently more valuable, he is trained in a method of study which is applicable to the problems of his daily life. He is continually confronted with the problem of action in the face of new situations. If he is trained to analyze specific situations and is taught to make generalizations from these he will be able to attack and master the problems which he will meet in life with increasing confidence.

The accompanying lessons will illustrate the manner in which the subject matter is presented and will also give the reader an idea of how the material from different parts of the text can be written into lessons with the activity of generalization as the explicit aim.

LESSON I—Test of Fundamental Powers

From your former studies in mathematics you have acquired a certain power to analyze geometric figures into elements, such as points, lines, etc., and to discover

*This experiment is being conducted with the help and advice of Dr. S. A. Courtis of the University of Michigan.

relations between these elements such as parallel lines, perpendicular lines, etc. In Plane Geometry, however, your opportunities to exercise your powers were limited because you were dealing with two dimensional space. Having exhausted the possibilities in such space, you are now ready to attack the same kind of problems in the next higher field, three dimensional space, the one in which we live.

The first step is to analyze solids into their elements and to discover the relations which exist between elements in three-dimensional space. You will be interested to see how many of the elements and relationships with which you are already familiar are to be found in the new field. Perhaps it will be even more interesting to discover which member of the class possesses the greatest powers of analysis and discovery.

As a challenge to your ability, your instructor proposes the following contest. On his desk are three solids, a cube, a parallelepiped, and a sphere. Let each member of the class make an independent analysis of these objects, writing a list of his discoveries. Look at the solids and list under "ELEMENTS" as many elements as you are able to discover, and under "Relationships" as many relations as you are able to discover. After you have listed as many of these as you can find try to generalize by grouping the elements and relations under general types. At the conclusion of the alloted time let us pool these discoveries and make a master list of the elements and relationships upon which we can agree. Then each person can check his list against the master list and find his score. The person with the highest score will win.

Specific Assignment

1. Examine the three solids on the instructor's desk.
2. Analyze them into elements and relationships.
3. List your discoveries under two headings: (1) Elements; and (2) Relationships. Write your list on a paper to hand in and sign it.
4. Be prepared to defend your discoveries to your classmates.
5. You will be given as much time as you need up to twenty minutes in which to make your list; the remainder of the class period will be devoted to determining the winners.

If you have any questions to ask about the paper raise your hand and I'll give you the assistance needed.

LESSON IX—Perpendicular Lines and Planes

If you have ever watched the construction of a modern skyscraper you doubtless observed that there were many

lines and planes both parallel and perpendicular to each other. Even in the construction of a small frame dwelling the carpenter is faced with the problem of erecting corner posts perpendicular to the plane of the floor. This lesson deals with the subject of perpendicular lines and planes.

The assignment which follows is divided into two parts. In the first part you will be given a number of exercises which deal with lines and planes in various positions. The purpose of these being to clarify your idea of a line perpendicular to a plane. In the second part you will be asked to list a number of specific theorems from Plane Geometry, and from these to make generalizations for like situations in space. This is in accordance with the idea that you have been following throughout this course; namely, to analyze specific situations and from these to make generalizations. On this basis solid geometry is merely a generalization of plane geometry.

Assignment

Part I

1. If a line on the blackboard is in a horizontal position state the position of a line on the board which is perpendicular to the first line.
2. If a line is drawn on this floor state the position of a second line on the floor which is perpendicular to the first.
3. In plane geometry state the number of lines which can be drawn perpendicular to a line at a given point on it.
4. In space, how many lines can be drawn perpendicular to a line at a given point on it?
5. In space, if a line is vertical, what is the position of all lines perpendicular to it at a given point?
6. In space, if a line is horizontal, what is the position of all lines perpendicular to it at a given point?
7. Write a competent definition of a line perpendicular to a plane.

Part II

1. In your text between the pages IX and XVIII you will find listed the principal theorems of plane geometry. Read this list and mark those which deal with perpendicular lines.
2. Write the theorems which you have marked on a clean sheet of paper, numbered 1, 2, 3, etc.
3. On another sheet of paper, numbered in the same manner, see if you are able to write for each plane geometry theorem a similar theorem for solid geometry.

LESSON XXI—Solids

So far you have made generalizations from plane geometry in which the elements were points and lines. You have discovered that similar situations arise in space between lines and planes. You have also discovered that this same relationship exists between angles in plane

geometry and angles between planes; called dihedral angles; polyhedral angles, etc. It will be interesting to see if this relationship exists between plane figures and solids. This lesson is planned to give you an opportunity to test your powers in discovering the properties of solid figures.

ASSIGNMENT

1. In plane geometry the general plane figure formed by straight lines is called, "polygon." Can you suggest a name for the general solid figure?

2. In plane geometry polygons are classified according to the number of sides; as triangles, quadrilaterals, pentagons, hexagons, etc. Can you suggest a way of classifying solid figures?

3. In polygons we have: (a) sides, (b) vertices, (c) angles, (d) diagonals (e) altitudes, (f) bases, etc. Is there a corresponding part in the solid figure for each of these? Make a list of the parts of the general solid figure.

4. In plane geometry we are able to find the properties, area, etc. of certain types of polygons. Is it possible to find the surface area, volume, etc. of certain solids? Wherein lies the difficulty of finding the surface area and volume of all solids?

5. What is the fewest number of lines that can form a polygon?

6. What is the fewest number of planes that can form a solid?

7. Can you derive a formula for the surface area (exclusive of bases) of a solid formed with rectangles between parallel bases? What is it?

8. Can you do the same for solids formed with parallelograms included between parallel bases?

9. Can you do the same for solids formed with equilateral triangles?

10. Can you do the same for solids formed with trapezoids of equal altitudes?

In the new method the formal proof is treated in a different manner from the conventional method of studying the proofs in the text and then reproducing them in a formal written or oral recitation. In the first place as an introduction to the formal proof of solid geometry the pupil is given a number of plane geometry proofs and then asked to analyze them with a view to listing the essential steps in the general pattern to which they all conform. Each of the steps is then analyzed and generalizations made therefrom. In addition a general plan of proof is made in each case. When the list is completed the pupil understands the proof so well that he is able to take up a new theorem or exercise and either prove it or locate for himself the exact place and cause of failure so that his request for help is intelligent and to the point.

As to the method of conducting the class the basic idea

is to shift the responsibility to the pupil. The teacher presents the problem and shares with the class his purpose. He then fades out of the picture as the student comes to the front to carry forward the work by self activity.

After each pupil has made an independent analysis of the problem, or problems in the assignment the class as a whole chooses the method which they desire to follow. Sometimes they meet in groups, elect a group chairman, and carry forward the work in this manner, marking those problems on which they wish to have general class discussion. At other times each checks his results with that member of the class nearest him. In the latter case when there is a disagreement each tries to sell his views to the other, and if they are still unable to agree the question is presented to the entire class for general discussion. Still on other occasions, particularly in exercise work, two members of the group choose teams and they work on a competitive basis. The rules in this case are definitely set forth. As a student finishes a proof he passes it to a member of the opposing team who must stop immediately to read it and pass upon it as right or wrong. The teacher acts as referee and keeps the records.

The writer has two classes in solid geometry, one conducted on conventional lines and the other using lesson sheets similar to those attached hereto and following the method described above. The two classes are approximately the same size and the average I. Q. for the two groups is very nearly the same, the average for the old group being 110.1 and for the new 108.3.

At the end of five weeks four tests, using exactly the same material and under exactly the same conditions, were given to the two groups. The first was a test on loci which follows:

Test

1. Describe the locus of points on this floor equidistant from the intersections with the floor of two opposite walls of the room.
2. Describe the locus of points in this room equidistant from two opposite walls of the room.
3. Describe the locus of points on this floor equidistant from the intersections with the floor of two adjacent walls of the room.
4. Describe the locus of points in this room equidistant from two adjacent walls of the room.
5. Draw a figure to represent the locus of points in space at a given distance from a given plane.

6. Draw a figure to represent the locus of points in space equidistant from the end points of a given line segment.

7. Draw a figure to represent the locus of points in space at a fixed distance from a given line.

8. Describe the locus of points in space at a fixed distance from a given point.

9. Describe the locus of all lines which pass through a fixed point and parallel to a given plane.

10. If a triangle ABC is rotated about its base as an axis what is the path, or locus, of its vertex?

11. If a rectangle ABCD is rotated about AB as an axis, what is the locus of CD? BC?

12. If a circle is rotated about a diameter as an axis, what is the locus of its circumference?

13. What is the locus of points in space equidistant from the vertices of a given triangle?

The group taught on conventional lines had encountered at least two of the problems asked, propositions XIV and XX in Durrell and Arnolds' new Solid Geometry. Also a number of exercises on the subject of locus had been discussed in this group. In the other group, conducted on the new plan, the subject of locus had not been discussed, and in fact the word had not been used in the class except as it was brought up in general class discussion in connection with the generalizations of plane geometry theorems. The percentage of rights in the class on the new plan, although it varied considerably with the difficulty of the problem, was uniformly higher than in the old group. Reduced to esochrons or units of growth the results showed that the group working under the new plan was achieving approximately 1.25 times that of the old group.

In the next test, given a few days later, each group was given fifteen minutes in which to answer the following questions: "List in abbreviated form as many conditions as you are able to list for determining (1) a line perpendicular to a plane (2) two planes parallel (3) two lines in space parallel." The new group was uniformly higher in the number of true conditions listed and lower in the number of false ones. To be exact the new group listed an average of 9.6 true conditions per pupil while the old group listed an average of 8.3. The new group listed an average of 1.1 false statements while the old group listed an average of 2.2 false statements. Subtracting the number of wrongs from the number of rights the comparison would stand 8.5 to 6.1.

The next day five minutes was allowed to give a complete proof of the exercise. "If a line and a plane are both parallel to the same line they are parallel to each other." In the new group 61 per cent of the class gave perfect demonstrations within the time limit of five minutes. 33⅓ per cent gave partial solutions, correct except that the condition assumed was not general. In the old group only 40 per cent gave perfect solutions and 20 per cent gave partial solutions.

The final test was based on the formal proofs of the text which had been studied by both groups. The following questions were asked: (1) Make a complete drawing, one that would be used in proving the theorem: From an external point one and only one perpendicular to a plane can be drawn. (2) Assuming line AB perpendicular to plane MN at B prove that AB is the only perpendicular possible to MN at B. (3) Explain with the aid of a lettered figure the construction steps only for proving: two lines perpendicular to the same plane are parallel. (4) Prove: If a line is perpendicular to a plane every plane containing the line is perpendicular to the plane.

The grades for the individuals were computed on a percentage basis and the average obtained for each group. The average for the group taught on the new plan was 88 as opposed to 74 for the group taught on conventional lines.

Based on the results of the tests to date and the experience of the writer in working with the group the following conclusion seem to be justified. In the first place it should be clearly understood that in the new method there is no sacrificing of subject matter. It is true that the subject matter has to be somewhat limited. It is impossible to cover as much ground using the new method as with the conventional method of teaching in which subject matter is the chief goal. It is also true that the mere acquisition of facts is pushed into the background and the growth of the student in such virtues as vision, self appraisal, self control and cooperation become the guiding factors in the activities of the class. Nevertheless, the pupil himself realizes the need of mastery of the subject matter in order to carry for-

ward the activities of the class in his own best interest. He experiences a real need of mastering certain material and therefore learns it for his own good.

Under the new plan the student attacks new situations with confidence. He is taught to see problems, to make plans, and to act in the face of new situations. There is never any stalling. If the instructions are clear, the fact that the material is new does not frighten him. He proceeds to analyze the new material and reach conclusions which to him seem justifiable, on the basis of experience and information at hand.

The new method stimulates thought. The pupil is no longer learning facts from a text but is carrying forward activities which call for individual thinking.

The new method creates a healthy attitude towards work. There is a feeling of ownership in the work done because the conclusions reached are the results of the student's own creative thinking.

The new method furnishes motivation on a high plane. The pupil realizes in the beginning the purpose of the activity and he carries it forward with interest. He realizes too that he is sharing in the activities selected and that his position and standing is determined by his own cooperation and contribution.

A LIBERAL EDUCATION

"That man, I think, has a liberal education who has been so trained in his youth that his body is the ready servant of his will and does with ease and pleasure all the work that, as a mechanism it is capable of; whose intellect is a clear, cold logic engine, with all its parts of equal strength and in smooth working order, ready like a steam engine, to spin the gossamers as well as forge the anchors of the mind, whose mind is stored with a knowledge of the great and fundamental truths of nature and the laws of her operations, one who, no stinted ascetic, is full of life and fire, but whose passions are trained to come to heat by a vigorous will, the servant of a tender conscience; who has learned to love all beauty whether of nature or of art, to hate all vileness, and to respect others as human."—Thomas Huxley, address to a Workingmen's College.

EARLY VALENCE THEORIES

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With the recent introduction of the electron theory as the basis of interpreting chemical action, the question of valence has received a great deal of consideration. Varied views as to the exact mechanism of valence in both organic and inorganic compounds have been expounded in a large number of texts, and perfect accord as to exactly what happens when elements combine is not yet in sight. It might be interesting to review several valence theories which have had their day at one time or another. The historical aspect of valence is rarely emphasized, but the roots of our modern theory can be traced back a long way.

As far back as 1820, Johann Jacob Berzelius in his "Versuch uber die Theorie der chemischen Proportionen und uber die chemischen Wirkungen der Electrizitat" advanced a view which is strikingly similar to our own electron theory in that it is electrochemical in nature. He was brought to this view by the then recent work of Volta and Sir Humphry Davy who demonstrated the production of static electricity and its subsequent destruction when oppositely charged compounds were brought together. Berzelius claimed that elements possessed a varied amount of positive and negative electricity and were oppositely attracted. The element sodium had positive electricity and oxygen negative. When they combined, sodium oxide was the result. Such a compound might as a result be neutral, but in the case of sodium oxide the resulting compound was still positive because sodium contained a larger amount of positive electricity than oxygen contained of the negative variety. Similarly, sulphur united with oxygen, but in this case the large excess of oxygen's negative electricity caused sulphur trioxide to be negative. Now the sodium oxide might unite with sulphur trioxide because of their opposite charge and form sodium sulphate:

$$\overset{+}{\mathrm{NaO}} + \overset{-}{\mathrm{SO_3}} = \mathrm{NaO.\,SO_3}$$

Berzelius called sodium sulphate a compound of the

second order. Further combinations like these might result in compounds of the third order, i. e., double salts.

Berzelius "Dualistic Theory" as it was called became the guide for observations in chemistry for several decades until the French chemist, Dumas, and his pupil, Laurent, developed the "Unitary Theory," which became the "Theory of Types" and eventually led to the conception of valence as a substitution or replacement value.

In 1833, Dumas, working on the action of chlorine on alcohol, discovered that the halogens could be introduced into organic compounds and replace the element hydrogen. Berzelius objected strongly to any such statement, because, asked he, how could negative chlorine replace positive hydrogen? Dumas, in 1839, noticed that he was able to produce trichloracetic acid from acetic acid and chlorine and that both acids resembled each other. He now advanced the proposition that compounds formed as a result of substitution behaved like the original substance (1). This idea started what is known as the "Theory of Types." It absolutely disregarded any notion of electricity and was, therefore, in direct opposition to Berzelius' "Electrochemical Theory."

The proponents of each theory vehemently opposed each other's views for a long time until Gerhardt, in 1866, more or less combined the two by introducing a series of simple inorganic types from which complex compounds could be derived by substituting organic radicals for the hydrogen atoms of the simple type substance. His classification included (a) the H. H. type, such as ethane, which is obtained by substituting the ethyl radical, C_2H_5, for one hydrogen atom (b) the HCl type, such as ethyl chloride, C_2H_5Cl (c) the HOH type such as ethyl alcohol, C_2H_5OH and (d) the H_3N type, such as ethyl amine, $C_2H_5H_2N$.

It was from the study of these types that the recent ideas of valency seem to have originated. Williamson (2), for instance, in 1852, represented the conversion of potassium hydroxide into potassium carbonate by assuming that carbon moxide displaced two atoms of hydrogen in potassium hydroxide which he represented as K_2H_2-O_2, i. e.:

$$\begin{matrix} K_2O_2 & & K_2O_2 \\ H_2 & \rightarrow & CO \end{matrix}$$

He actually suggested that a molecule of carbon monoxide was equivalent to two atoms of hydrogen.

In 1852, Frankland put forward the conception of a definite combining power for each element. In his own words he says, "The compounds of nitrogen, phosphorus, antimony and arsenic especially exhibit the tendency of these elements to form compounds containing three or five equivalents of other elements and it is in these proportions that their affinities are best satisfied." This seems to be the clearest statement of the idea of valence that had been delivered up to that time.

Odling (3), in 1855, seems to have been the first to use the plan of marking the so-called substitution value of the element by one, or more short upright strokes to the right of the symbol, thus, H′, Bi‴, etc.

But it remained for Kekulé (4) to show clearly in 1857 that each element could be assigned a "substitution value." In his paper on "Copulated Compounds and Theories of Polyatomic Radicals" he writes, "From this point of view the elements fall into three principal groups:

(1) Monobasic or monatomic, H, Cl, Br, K.
(2) Dibasic or diatomic, O, S
(3) Tribasic or triatomic, N, P, As."

In 1857, Kekulé also added the so-called Marsh Gas Type to the four already suggested by Gerhardt. From a study of marsh gas and its derivatives, methyl chloride, chloroform, etc., he then came to the conclusion which has played such a large part in organic chemistry, namely, that carbon is tetravalent (5).

We thus find that at this point in Kekulé's work the ideas of valency are practically the same as those in vogue before the advent of the electron theory. As a matter of fact, the time-honored method of teaching valence consisted in pointing out the four type compounds, HCl, H_2O, H_3N and H_4C and noting that in each case the element other than hydrogen was able to combine with or replace different numbers of hydrogen atoms and this number was then the valence of the element.

This "type" idea also persists to a very large extent and is of great help in the teaching of organic chemistry. For instance, textbooks compare alcohols to water where an alkyl radical replaces one of the hydrogen atoms and in ethers both hydrogen atoms are replaced by alkyl radicals, etc.

It should be noted that Kekulé's ideas were not immediately accepted. Kekulé (6) emphasized one point, namely, that the valency or "atomicity" is a fundamental property of the atom which must be constant and invariable like the weight of the atom itself. For example, he did not admit that the valence of nitrogen changed in going from ammonia to ammonium chloride and he viewed the latter as $NH_3.HCl$ with the nitrogen still trivalent. Frankland, in 1852, as pointed out above, had already adopted the idea of variable valence and now Gerhardt developed the conception of "Maximum Saturation Capacity" in which it was stated that nitrogen, for example, might exercise a valence of three although its maximum valence was five. Kekulé objected to this (6). Erlenmeyer called compounds in which nitrogen had the lower valence "unsaturated." Kekulé at first opposed these views, but he could not help noticing (8) that certain compounds, i. e., ethylene and its derivatives were able to add on hydrogen, bromine, etc., and he, therefore, adopted the idea that "two units of affinity of the carbon atom are unsaturated."

At any rate, discussions centering around unsaturation and variable valences have never been fully settled. Johannes Thiele's theory of partial valences which made its appearance in 1899 as a result of his work on the conjugated double bond in organic chemistry, and Werner's ideas involving auxiliary valences are but two of the several conceptions which attempt to explain these problems (7).

Any comment on valency cannot be left without some reference to its important assistant, particularly in the field of organic chemistry, namely, the structural formula, by the use of which the valence, state of saturation and relation of the atoms to each other can be represented pictorially. In 1861 Kekulé (9) revived Dalton's use of graphic formulas, circles of various sizes for dif-

ferent elements to show not only the number of atoms as Dalton had done, but also to point out how the atoms were linked together. Later, Erlenmeyer began representing elements by letters and thus, by 1870, structural formulas looked much as they do today.

In 1865, Kekulé's attention was arrested by the fact that the benzene nucleus seems to behave as a unit in passing to its derivatives. He suspected that benzene itself consists of a close union of carbon atoms. In order to show this, and at the same time, satisfy his idea concerning the tetravalence of carbon, he published (10) his famous benzene ring, which is still accepted to-day. This served to explain most of the configurations of the aromatic compounds and their isomers, but the presence of stereoisomers could not yet be accounted for.

Pasteur had detected several optically active types of tartaric acid in his well known work on that compound. Other chemists had added aspartic, malic and lactic acids to this list, but it remained for Jacobus Henricus Van't Hoff in 1874 to visualize the carbon atom at the center of a tetrahedron, thereby furnishing chemical science with an idea which enabled Baeyer in 1885 to advance his "Strain Theory" (11) which still persists today. By means of the tetrahedron, stereoisomers are nicely explained. The most important point which Van't Hoff's tetrahedron emphasizes is the fact that the four valences of carbon do not lie in the same plane, and the difference in the properties of the isomers is due to the fact that there is a difference in the arrangement of the atoms of the isomers in space.

It was thus that matters stood when the discovery of radium by the Curies provided an insight into the structure of the atom and caused chemists and physicists to place the electron arrangement of the atom as the underlying cause of its valence.

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FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE

BY DUANE ROLLER,

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If I had my life to live over again, I would have made a rule to read some poetry and listen to some music at least once a week; for perhaps the parts of my brain now atrophied would thus have been kept active through use. The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature.—*Charles Darwin.*

Music is to me the symbol by which one may invade the enchanted province of nothing and find one's way. By following its directions, I feel that in some inexplicable way one perceives lines upon which the universe is coördinated. All other arts are more or less dimensionally confined, the boundaries clearly marked out and all-contained.—*Muriel Draper, "Music at Midnight."*

Science surpasses the old miracles of mythology.—*R. W. Emerson.*

I'd rather talk science to a wide-awake Boy Scout than to some sleepy grownups.—*W. J. Humphreys, physicist, U. S. Weather Bureau.*

Linnaeus and Cuvier have been my two gods, though in very different ways; but they were mere schoolboys compared to old Aristotle.—*Charles Darwin.*

My share of the work of the world may be limited, but the fact that it is work makes it precious. Darwin could work only half an hour at a time; yet in many diligent half hours he laid anew the foundations of philosophy.—*Helen Keller.*

Oh, Constellations of the early night
That sparkled brighter as the twilight died,
And made the darkness glorious! I have seen
Your rays grow dim upon the horizon's edge,
And sink behind the mountains. I have seen
The great Orion, with his jewelled belt,
That large-limbed warrior of the skies, go down
Into the gloom. Beside him sank a crowd
Of shining ones.

—*William Cullen Bryant, "The Constellations."*

FRACTIONAL, ZERO AND NEGATIVE EXPONENTS

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Meaning and Use of a Fractional Exponent

1. (a) The number 9 is the product of two equal factors, 3 and 3, that is, 9 is the square of 3, hence 3 is called the square root of 9. This number may be expressed with the exponent 1, as 9^1, and the square root of it may be indicated by means of a fractional exponent whose numerator is 1, the exponent of 9, and whose denominator is 2, the index of the square root, that is $9^{\frac{1}{2}}$ indicates *one* of the *two* equal factors whose product is 9^1 or 9.

As stated above, since $9^1=3\times3$, which equals 3^2, then $9^{\frac{1}{2}}=3$.

(b) Since the product of -3 and -3 is 9, -3 may also be considered as the square root of 9, that is, the square root of 9 is either $+3$ or -3.

2. The number 8 is the product of three equal factors, 2, 2, and 2, that is 8 is the cube of 2, hence 2 is called the cube root of 8. This number may be expressed with the exponent 1, as 8^1, and the cube root of it may be indicated by a fractional exponent whose numerator is 1, the exponent of 8, and whose denominator is 3, the index of the required root, that is, $8^{\frac{1}{3}}$ indicates *one* of the *three* equal factors whose product is 8^1 or 8. These statements may be condensed as follows:

Since $8^1=2\times2\times2$, which equals 2^3, then $8^{\frac{1}{3}}=2$.

3. (a) As a symbol of operation, in the expression $(81)^{\frac{1}{4}}$ the exponent $\frac{1}{4}$ shows that one of four equal factors whose product is 81 is indicated or required. Since 81, or $(81)^1=3\times3\times3\times3$, which equals 3^4, then $(81)^{\frac{1}{4}}=3$.

(b) Since the product of the four equal factors, -3, -3, -3, and -3 is 81, then the fourth root of 81 is either $+3$, as shown in (a), or -3, that is $(81)^{\frac{1}{4}}=\pm3$.

4. An odd root of a positive number is positive and an even root is either positive or negative. An odd root of a negative number is negative, as, the cube root of -64 is -4, since $(-4)^3=-64$.

5. The odd root of a positive number, the even positive root

of a positive number, and the odd root of a negative number, are each called the principal root of the given number. Principal roots only will be considered in the following discussion.

6. A root of a number is one of a definite number of equal factors of the number whose product is the number itself.

7. A root of a number may be indicated by means of a fractional exponent whose numerator is 1 and whose denominator is the index of the required root.

8. The Radical Sign with its Index as a Symbol of Operation.

The square root of 9 may be indicated by means of the fractional exponent $\frac{1}{2}$, or by means of a radical sign with the denominator of the fractional exponent as the index of the radical sign. The numerator 1 may then be used as the exponent of the number 9, as in Par. 1, (a), and $9^{\frac{1}{2}}$ may be expressed as $\sqrt[2]{9^1}$. The cube root of 8 may be indicated by the fractional exponent $\frac{1}{3}$, or by means of a radical sign with the denominator of the fractional exponent as the index of the radical sign. The numerator 1 may then be used as the exponent of 8, as in Par. 1, (b), and $8^{\frac{1}{3}}$ may be expressed as $\sqrt[3]{8^1}$. Similarly, the fourth root of 81 may be indicated as $(81)^{\frac{1}{4}}$, or as $\sqrt[4]{(81)^1}$, and the nth root of a may be indicated as $a^{\frac{1}{n}}$, or as $\sqrt[n]{a^1}$.

9. A root of a number may be indicated by means of a fractional exponent whose numerator is 1 and whose denominator is the index of the required root, or by means of a radical sign with its index which corresponds to the denominator of the fractional exponent. The number 1, which corresponds to the numerator of the fractional exponent, may be used as the exponent of the number under the radical sign, as shown in Par. 8.

10. Exercises.

1. (a) Name the equal factors of each of the following numbers: 4, 12, 9, 18, 27, 54, 16, 48, 25, 125.

(b) State for each number in (a), whether the equal factors named are roots of the given number or factors only.

2. (a) Indicate by means of a fractional exponent the square root of 4, 25, a; the cube root of 27, -27, 64, -64, a; the fourth root of 16; the fifth root of 32; the nth root of x.

(b) Indicate by means of a radical sign with its index the required roots of the numbers in (a), using the numerator of

the fractional exponent in each case as the exponent of the number under the radical sign.

3. Perform the following indicated operations: $(16)^{\frac{1}{2}}$; $(16)^{\frac{1}{4}}$; $(32)^{\frac{1}{5}}$; $(-32)^{\frac{1}{5}}$; $(125)^{\frac{1}{3}}$; $\sqrt[3]{27}$; $\sqrt[3]{-27}$; $\sqrt[3]{64}$; $\sqrt[3]{-64}$; $\sqrt[4]{625}$; $\sqrt[3]{-1}$.

11. Meaning of a Fractional Exponent whose Numerator is not 1.

1. (a) I. The product of $a^{\frac{1}{3}}$ and $a^{\frac{1}{3}}$, or the square of $a^{\frac{1}{3}}$, may be expressed as $(a^{\frac{1}{3}})^2$. In this expression the exponent 2 indicates a power and the exponent $\frac{1}{3}$ indicates a root, that is, $(a^{\frac{1}{3}})^2$ indicates the *square* of the *cube root* of *a*. II. But $(a^{\frac{1}{3}})^2$ is equal to $a^{\frac{1}{3}\times 2}$, or $a^{\frac{2}{3}}$, since the exponent of the power of a number is the product of the exponent of the number and the index of the required power. Hence, from I and II, $a^{\frac{2}{3}}$ indicates the square of the cube root of *a*. These statements may be condensed as follows: $(a^{\frac{1}{3}})(a^{\frac{1}{3}}) = (a^{\frac{1}{3}})^2$, which equals $a^{\frac{1}{3}\times 2}$, which equals $a^{\frac{2}{3}}$.

(b) I. The product $[(a)(a)]^{\frac{1}{3}}$ may be expressed as $(a^2)^{\frac{1}{3}}$, which indicates the *cube root* of the *square* of a. II. But $(a^2)^{\frac{1}{3}}$ is equal to $a^{2\times\frac{1}{3}}$, or $a^{\frac{2}{3}}$. Hence from I and II, $a^{\frac{2}{3}}$ indicates the cube root of the square of a. Statements I and II may be condensed as follows: $[(a)(a)]^{\frac{1}{3}}$ equals $(a^2)^{\frac{1}{3}}$, which equals $a^{2\times\frac{1}{3}}$, which equals $a^{\frac{2}{3}}$.

(c) If a equals 8 in (a) and (b), then by substitution,

I. $a^{\frac{2}{3}} = (a^{\frac{1}{3}})^2 = (8^{\frac{1}{3}})^2 = (2)^2 = 4$, and

II. $a^{\frac{2}{3}} = (a^2)^{\frac{1}{3}} = (8^2)^{\frac{1}{3}} = (64)^{\frac{1}{3}} = 4.$

From I and II, since the square of the cube root of 8 is equal to the cube root of the square of 8, it is a matter of expediency which operation is performed first.

12. A fractional exponent whose numerator is not 1 indicates both a root and a power, the denominator indicating a root and the numerator a power. The fractional exponent whose numerator is 1, by definition indicates a root, but since this root is one of the equal factors of a number whose product is the number itself, that is, the first power of the number, then in

general, a positive fractional exponent indicates both a root and a power.

13. A fractional exponent indicates both a root and a power of a number but a radical sign with its index indicates a root of a number only, hence in changing from the first form to the second, the power which is indicated by the numerator of the fractional exponent must be indicated by the exponent of the number under the radical sign, as, the cube root of the square of a is indicated either as $(a^2)^{\frac{1}{3}}$, which equals $a^{2\times\frac{1}{3}}$ or $a^{\frac{2}{3}}$, or it may be indicated as $\sqrt[3]{(a^2)^1}$, which equals $\sqrt[3]{a^{2\times1}}$, or $\sqrt[3]{a^2}$. The nth root of the mth power of a may be indicated as $(a^m)^{\frac{1}{n}}$, which equals $a^{m\times\frac{1}{n}}$ or $a^{\frac{m}{n}}$, or it may be indicated as $\sqrt[n]{(a^m)^1}$, which equals $\sqrt[n]{a^{m\times1}}$, or $\sqrt[n]{a^m}$.

14. Exercises.

1. (a) Show the two operations that are indicated in each of the following expressions, making use of the unit fraction in each case to indicate a root: $4^{\frac{2}{3}}$ $6^{\frac{2}{3}}$ $7^{\frac{3}{4}}$ $9^{\frac{4}{5}}$ $a^{\frac{x}{y}}$.

(b) Show the two operations that are indicated in each of the expressions in (a), using a radical sign with its index instead of a fractional exponent, and showing how the numerator of the unit fraction used in each expression in (a) can also be used in (b).

2. Show the operations that are indicated in each of the following expressions, making use of the radical sign with its index and using integral exponents only: $a^{\frac{2}{5}}$; $b^{\frac{4}{3}}$; $c^{\frac{5}{4}}$; $x^{\frac{1}{2}}$.

3. Perform so far as possible the operations indicated in each of the following expressions: $(25)^{\frac{3}{2}}$; $5^{\frac{3}{2}}$; $6^{\frac{2}{3}}$; $(27)^{\frac{2}{3}}$; $(16)^{\frac{3}{4}}$; $(32)^{\frac{2}{5}}$; $(81)^{\frac{1}{2}}$; $(81)^{\frac{1}{4}}$; $\sqrt{9}$; $\sqrt[3]{8}$; $\sqrt[3]{64}$; $\sqrt{5^2}$; $\sqrt[3]{7^2}$.

15. Root of a Power the Exponent of which is a Multiple of the Index of the Root.

1. (a) The expression $(a^6)^{\frac{1}{3}}$ indicates the cube root of the sixth power of a, and since a^6 is the product of three equal factors, a^2, a^2, and a^2, one of these factors, a^2, is the cube root of a^6, that is, since $a^6 = (a^2)\ (a^2)\ (a^2)$ which equals $(a^2)^3$, then $(a^6)^{\frac{1}{3}} = a^2$.

(b) The root obtained in (a) may also be obtained as follows: $(a^6)^{\frac{1}{3}} = a^{6\times\frac{1}{3}}$ or $(a)^{\frac{6}{3}}$, which equals $a^{6\div3}$, which equals a^2. In this operation, the exponent of a^2, the cube root of a^6, is obtained by

dividing the exponent of a^6 by 3, the index of the required root. In general, for positive exponents, since the exponent of a power of a number is the product of the exponent of the number and the index of the required power, then conversely, the exponent of a root of a number is the quotient of the exponent of the number divided by the index of the required root.

2. Exercises.

I. Name the exponent of the root which is indicated in each of the following expressions: $(a^4)^{\frac{1}{2}}$; $(a^6)^{\frac{1}{2}}$; $(a^8)^{\frac{1}{2}}$; $(a^8)^{\frac{1}{4}}$; $(a^5)^{\frac{1}{2}}$; $(a^{2m})^{\frac{1}{m}}$; $\sqrt[2]{b^4}$; $\sqrt[3]{b^6}$; $\sqrt[2]{b^8}$; $\sqrt[4]{b^8}$; $\sqrt[2]{b^5}$; $\sqrt[x]{b^{3x}}$.

II. Perform the following indicated operations and show in each case how the root can be obtained in two different ways: $(a^2)^{\frac{1}{3}}$; $(a^4)^{\frac{1}{2}}$; $(3^2)^{\frac{1}{2}}$; $(3^4)^{\frac{1}{2}}$; $(3^4)^{\frac{1}{4}}$; $(25)^{\frac{1}{2}}$; $(125)^{\frac{1}{3}}$; $\sqrt[3]{-125}$; $\sqrt[4]{16}$; $\sqrt[7]{-128}$; $\sqrt[7]{128}$.

ZERO AND NEGATIVE EXPONENTS.

16. The Zero Exponent.

1. (a) In dividing a monomial by a monomial, by the law of exponents in the division of monomials, the exponent of the quotient is obtained by substracting the exponent of the divisor from the exponent of the dividend, as $a^3 \div a^3$, or expressed in the form $\frac{a^3}{a^3}$, equals a^{3-3}, which equals a^0. This form arises in the division of monomials if the exponent of the dividend is equal to the exponent of the divisor.

(b) The numerical value of a^0 is obtained as follows:

I. $\frac{a^3}{a^3}=a^{3-3}$, which equals a^0, as shown in (a); but

II. $\frac{a^3}{a^3}=1$, the quotient of a number divided by itself is 1; hence from I and II,

III. $a^0=1$, two quantities equal to the same quantity are equal.

(c) If a equals 5 in (b), then by substitution,

I. $\frac{a^3}{a^3}=\frac{5^3}{5^3}=5^{3-3}$, which equals 5^0; and II. $\frac{5^3}{5^3}=1$; hence from I and II, $5^0=1$.

(d) For any positive exponent as n,

I. $\frac{a^n}{a^n}=a^{n-n}=a^0$, and II. $\frac{a^n}{a^n}=1$; hence from I and II, $a^0=1$.

In general, the numerical value of a quantity with a zero exponent is 1.

(e) The fact that the numerical value of a quantity with a zero exponent is 1 shows why, in the arrangement of the terms of a polynomial in the order of the ascending or descending powers of a given quantity, the numerical term, if there be one, should be placed either as the first or the last term of the given polynomial, as $1+a+a^2+a^3$ represents $a^0+a^1+a^2+a^3$, the first term, a^0, being equal to 1. The polynomial $a^3+3+a+a^2$, arranged in the order of the descending powers of a becomes $a^3+a^2+a^1+3\ (a^0)$, and since $3(a^0)=3(1)$, which equals 3, the given polynomial is a^3+a^2+a+3.

2. Exercises.

I. (a) State what the exponent of x in each of the following indicated quotients is, and how it is obtained: $x^2 \div x^2$; $x^4 \div x^4$; $x^1 \div x^1$; $x^m \div x^m$; $x^0 \div x^0$.

(b) Substitute 10 for x in each of the exercises in (a), and state what the exponent of 10 in each of the indicated quotients is.

II. Show that each quotient in exercise 1, (b) is numerically equal to 1.

III. Find the numerical value of $2x^0$; $5x^0y^0$; $\frac{3x^0}{y^0}$; $\frac{x^0}{7y^0}$ for $x=10$ and $y=1$.

17. The Negative Exponent.

1. (a) In dividing a^2 by a^3, by the law of exponents in the division of monomials, the exponent of a in the quotient is $2-3$, or -1, as, $a^2 \div a^3 = a^{2-3}$, which equals a^{-1}. This form arises in the division of monomials if the exponent of the dividend is less numerically than the exponent of the divisor.

(b) The quantity a^{-1} may be expressed in the form $\frac{1}{a}$, for

I. $\frac{a^2}{a^3}=a^{2-3}$, which equals a^{-1}, and

II. $\frac{a^2}{a^3}=\frac{a^2(1)}{a^3(a)}=\frac{1}{a}$, by dividing both terms by a^2, hence from I and II,

III. $a^{-1}=\frac{1}{a}$.

(c) If a equals 4 in exercise (b), then by substitution,

I. $\frac{a^2}{a^3}=\frac{4^2}{4^3}=(4)^{2-3}=(4)^{-1}$,

II. But $\frac{4^2}{4^3}=\frac{4^2(1)}{4^2(4)}=\frac{16(1)}{16(4)}=\frac{1}{4}$,

III. Hence from I and II, $4^{-1}=\frac{1}{4}$.

(d) If a equals 10 in the expression $a \div a^3$, then by substitution,

I. $\frac{a}{a^3}=\frac{a^1}{a^3}=\frac{(10)^1}{(10)^3}=(10)^{1-3}=(10)^{-2}$, and

II. $\frac{(10)^1}{(10)^3}=\frac{(10)^1(1)}{(10)^1(10)^2}=\frac{1}{(10)^2}$ Hence from I and II, $(10)^{-2}=\frac{1}{(10)^2}$.

(e) I. $a^n \div a^{2n}=a^{n-2n}=a^{-n}$, n being positive and

II. $a^n \div a^{3n}=a^{n-3n}=a^{-2n}$, and so on. a^{-n} may be expressed as $\frac{1}{a^n}$, and a^{-2n} may be expressed as $\frac{1}{a^{2n}}$. In general, a number with a negative exponent is equal to 1 divided by the number with its exponent positive instead of negative, that is, a number with a negative exponent may be expressed in the form of a fraction whose numerator is 1 and whose denominator is the given number with its exponent positive instead of negative.

2. Exercises.

I. State what the exponent of x is in each of the following indicated quotients, and how it is obtained: $x^3 \div x^4$; $x^0 \div x^1$; $x^m \div x^{2m}$; $x^m \div x^{4m}$; $x^{-1} \div x^2$; $x^3 \div x^{-1}$.

II. Substitute 10 for x in each expression in exercise I, and find the numerical value of each quotient, expressed as a fraction, m being equal to 1.

III. Express as integers: $\frac{1}{a}$, $\frac{1}{a^2}$, $\frac{1}{a^3}$, $\frac{1}{10}$, $\frac{1}{(10)^2}$, $\frac{1}{(10)^3}$, $\frac{1}{(10)^4}$.

IV. Reduce each of the following fractions to the form of an integer, as shown in the following illustration:

$\frac{3}{a^2}=\frac{3(1)}{a^2}$ or $3\left[\frac{1}{a^2}\right]$ which equals $3\left[\frac{a^{-2}}{1}\right]$ or $\frac{3a^{-2}}{1}$ which equals $3a^{-2}$.

$\frac{2}{x}$; $\frac{4}{x^3}$; $\frac{5a}{a^4}$; $\frac{6x^{-1}}{3x}$; $\frac{8x}{4x^3}$; $\frac{6x}{3x^{-1}}$.

V. Reduce each of the following fractions so that all of the literal factors will appear in the numerator.

$\frac{9ab}{3a^2b^3}$; $\frac{4a^2b^2}{2ab}$; $\frac{4a^2b^2}{8a^0b^0}$; $\frac{3a^{-1}b^{-1}}{5ab}$; $\frac{3}{5ab}$.

18. Fractional Exponents Expressed in Decimal Form.

1. The square root of a number is indicated by the fractional exponent ½, and since this fraction expressed in decimal form is .5, the square root of a number may also be indicated by the decimal .5 used as an exponent, as $a^{\frac{1}{2}}$ is equivalent to $a^{.5}$. If the numerical value of a is 9, then $a^{\frac{1}{2}}=9^{\frac{1}{2}}$ which equals $9^{.5}$, and the square root of this number is 3.

2. The fourth root of a number is indicated by the fractional exponent ¼ and since this fraction expressed in decimal form is

.25, the fourth root of a number may also be indicated by this decimal used as an exponent, as $a^{\frac{1}{4}} = a^{.25}$. If the numerical value of a is 81, then $a^{\frac{1}{4}} = (81)^{\frac{1}{4}} = (81)^{.25}$ which equals 3.

3. (a) The expression $a^{\frac{3}{4}}$ indicates either the cube of the fourth root of a, or the fourth root of the cube of a. If a equals 16, then.

I. $a^{\frac{3}{4}} = (16)^{\frac{3}{4}} = [(16)^{\frac{1}{4}}]^3 = (2)^3 = 8$, or

II. $a^{\frac{3}{4}} = (16)^{\frac{3}{4}} = [(16)^3]^{\frac{1}{4}} = (16 x 16 x 16)^{\frac{1}{4}} = [(2^4)(2^4)(2^4)]^{\frac{1}{4}} = (2)^3 = 8$.

The expression $a^{\frac{3}{4}}$ indicates both a root and a power, and it is a matter of expediency which is obtained first.

(b) Since the exponent ¾ may be expressed as .75, then *a* being equal to 16, $a^{\frac{3}{4}} = (16)^{\frac{3}{4}} = (16)^{.75}$ which equals 8.

4. (a) The expression $a^{\frac{3}{2}}$ indicates either the cube of the square root of a, or the square root of the cube of a. If a equals 25, then

I. $a^{\frac{3}{2}} = (25)^{\frac{3}{2}} = [(25)^{\frac{1}{2}}]^3 = (5)^3 = 125$, or

II. $a^{\frac{3}{2}} = (25)^{\frac{3}{2}} = [(25)^3]^{\frac{1}{2}} = [(5^2)(5^2)(5^2)]^{\frac{1}{2}} = (5)^3 = 125$.

(b) Since $^3/_2$ expressed in decimal form is 1.5, then *a* being equal to 25, $a^{\frac{3}{2}} = (25)^{\frac{3}{2}} = (25)^{1.5} = 125$.

5. (a) The expression $a^{\frac{4}{3}}$ indicates either the fourth power of the cube root of a, or the cube root of the fourth power of a. If a equals 27.

I. $a^{\frac{4}{3}} = (27)^{\frac{4}{3}} = [(27)^{\frac{1}{3}}]^4 = (3)^4 = 81$, or

II. $a^{\frac{4}{3}} = (27)^{\frac{4}{3}} = [(27)^4]^{\frac{1}{3}} = [(3)^{12}]^{\frac{1}{3}} = (3)^4 = 81$.

(b) Since the fraction $^4/_3$ is equal to $1\frac{1}{3}$ which expressed as a decimal is $1.333\dot{3}$, then $(27)^{\frac{4}{3}} = (27)^{1.333\dot{3}}$, which equals 81.

6. Approximate Roots and Powers.

I. Illustrations.

1. Find the approximate root of $(10)^{.5}$.

Solution: $(10)^{.5}$ indicates the square root of 10, which is 3.162+, hence $(10)^{.5} = 3.162+$.

2. Find the approximate value of $(10)^{.25}$.

Solution: $(10)^{.25}$ indicates the fourth root of 10, hence $(10)^{.25} = 1.777+$.

3. Find the approximate value $(10)^{1.5}$.

Solution: Since 1.5 equals $1\frac{1}{2}$, or $^3/_2$, which used as the exponent of 10 indicates either the cube of the square root of 10, or the square root of the cube of 10, then,

I. $(10)^{1.5} = (10)^{\frac{3}{2}} = [(10)^{\frac{1}{2}}]^3 = (3.162)^3 = 31.62+$, or

II. $(10)^{1.5} = (10)^{\frac{3}{2}} = [(10)^3]^{\frac{1}{2}} = (1000)^{\frac{1}{2}} = 31.62+$.

4. Find the approximate value of $(10)^{2.5}$.

Solution: Since the exponent 2.5 is equal to $2\frac{1}{2}$, or $^5/_2$, then

$(10)^{2.5}=(10)^{\frac{5}{2}}$, which indicates either the fifth power of the square root of 10, or the square root of the fifth power of 10, as,

I. $(10)^{2.5}=(10)^{\frac{5}{2}}=[(10)^{\frac{1}{2}}]^5=(3.162)^5$, or

II. $(10)^{2.5}=(10)^{\frac{5}{2}}=[(10)^5]^{\frac{1}{2}}=(100000)^{\frac{1}{2}}=316.22+$.

II. Exercises.

1. Find approximate values of $8^{.5}$; $8^{.333\dot{3}}$; $8^{.666\dot{6}}$; 8^1; $8^{1.5}$; $8^{1.666\dot{6}}$; 8^2.

2. Find approximate values of $9^{2.50}$; $9^{2.750}$; $(10)^1$; $(10)^{1.750}$; $(10)^{2.50}$; $(10)^{.333\dot{3}}$; $(10)^{.666\dot{6}}$.

THE CLEVELAND PILGRIMAGE

After a lapse of twenty some years, the Central Association of Science and Mathematics Teachers will be the guests of their Cleveland brethren November 25 and 26, 1932. Though the wisdom of bringing the Association to Cleveland was questioned by some, the most skeptical would have been converted had he attended the first meeting of the Convention Committee, headed by E. O. Bower at a luncheon in the Cleveland Club. Inspired and guided by the charter members of the Central Association, Mr. Charles Marple and Mr. Franklin T. Jones, the committee charted its course in a very optimistic frame of mind.

Each committee member has gone over the top and the result is that we believe we have prepared one of the best General Programs ever to be presented to the Central Association. In addition to this, the sectional officers are to be congratulated upon the nationally famous mathematicians and scientists they have succeeded in inducing to appear on their programs.

The officers and Convention Committee sincerely hope that each section chairman will do everything within his power to insure a large attendance. A committee, for each section perhaps, should be appointed to ensure that the generosity and talent of all these speakers shall be recognized by an adequate attendance.

Let all members join immediately in a movement to make this meeting the beginning of a new era for the Central Association of Science and Mathematics Teachers. Membership and participation in the activities of the Association will then be a mark of professional distinction.

F. R. BEMISDERFER.

THE CARE AND BREEDING OF TROPICAL AQUARIUM FISHES[1]

BY MYRON GORDON,[2]
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I want to introduce you to a new hobby—the keeping and breeding of small tropical fresh-water fishes. Many of these fishes never grow larger than two or three inches and they may be cared for in a small aquarium in your own home. During the past few years this hobby has been taken up by a surprisingly large number of people. Some become interested in tropical fishes because they enjoy seeing beautiful living things. Other people, more practically minded, combine business with pleasure by raising a surplus and selling them to their neighbors and to dealers of pet stock.

When properly set up, an aquarium is beautiful and ornamental. The aquarium, with its living plants and animals, has a great appeal to nature students. Children, particularly, are fascinated by watching the activities of the lively fish. Everybody is interested in watching how these small living things eat, how they swim, how they behave towards one another, and particularly, how these fish breed and rear a family of young.

When I talk to visitors at my tropical fish laboratory and tell them that some of the tropical fishes do not lay eggs like most fish, but give birth to living young, they usually are very much surprised. "Why I thought that animals only did that," they say. You see, fishes are really very close to land animals in many respects. Their requirements for life are very much like our own. You must consider fishes as you do the other animals. They must have fresh air to breathe; good food to eat; they must be provided with a temperature to which they are accustomed, and finally some provision must be made for the removal of the waste products of their bodies.

Before buying tropical fishes, consider the kind and size of the aquarium that you need. Buy one, not less than twelve inches long, because you will want to add to your original purchases. For greatest service and satisfaction, the

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[1]Radio talk given October 27, 1931, over WEAI, Cornell University Station.

[2]Investigator, Project No. 106; STUDIES ON THE ORIGIN OF NEOPLASTIC DISEASES (MELANOSIS) IN FISHES, supported by the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University, Ithaca, N. Y.

aquarium with a metal frame and glass sides and the bottom of either slate or glass is best. Contrary to general opinions on the subject, they are not necessarily more expensive than those which are made of glass entirely. But they are much stronger, better looking and better for the fishes. These aquaria may now be bought with frames of various metals: galvanized iron, aluminum, monel metal and stainless steel.

Tropical fishes are smaller than goldfish, on the average. More of them can be kept in an aquarium and the dangers of crowding are not as great. Nevertheless remember that if you want your fishes to be kept in good breeding condition, they must have plenty of room. I would say that a pair of tropical fish should have at least one gallon of water.

Tap water from the city supply is often not suitable for tropical fishes because of the chlorin and lime which is put into it. It is far better to go to the nearest stream and take water there. Water from deep wells and springs may be used but it must be poured back and forth to aerate it.

The aquarium should have water plants. They add beauty beauty to the aquarium and they help to keep the water pure and clean. In growth they give off oxygen which the fishes need. At the same time they take up some of the waste products from the water such as carbon dioxide. Plants also use a good deal of the injurious portions of the refuse, such as the droppings and the uneaten part of the food. If you get the plants to grow well in your aquarium it will not be necessary for you to change the water at all.

The bottom of the aquarium should be covered with an inch of fine bird gravel. Plants with long root systems are very helpful in keeping healthy conditions in the aquarium. Plants of this nature are the eel grasses, *Vallisneria* and *Sagittaria*. They are inexpensive and multiply rapidly. Other types of water weeds are useful such as the common water weed, *Elodea*.

Those who expect to raise young fishes must obtain plants that grow in dense masses in which young fish may find shelter. Parental care of the young is hardly developed in these fishes. They will hunt down anything that moves and looks like food. When hungry they would just as soon eat their own young as small worms. Plants such as crystalwort,

small bladderwort and dense growths of *Elodea* make excellent hiding places for young fishes.

Plants cannot do useful work in the aquarium without proper light. When the aquarium is placed in a dark spot, no plant growth will take place. On the other hand, it is not desirable to place the aquarium where the sun is strong because the aquarium will heat up quickly. It also induces the growth of undesirable microscopic plant life which results in the water of the aquarium turning a deep green. Green water is not harmful. On the contrary it is beneficial but, it is decidedly unpleasant. Often you can control the development of green water by cutting off some of the light, as, for example, by shading with a piece of paper that side of the aquarium which faces the window. Northern or eastern exposure usually gives the best light conditions for an aquarium.

In feeding fishes remember they are very small and do not need much food. You can save yourself a great deal of trouble and the fishes will get along much better if you feed no more than they will eat up within an hour. Fishes will naturally gorge themselves with food. Like most wild animals, they must eat rapidly and then seek shelter. The real danger in overfeeding comes from the spoiling of the uneaten food. Milky water is caused by aquatic bacteria which break down the surplus food. In so doing bacteria rob the water of its oxygen. Most of you have seen fishes swimming at the surface of the aquarium sticking their snouts into the air. They are trying to get fresh air. It is a sign that something is wrong in the aquarium. When this happens, stop feeding entirely until the water clears up again. These suggestions only apply if the aquarium is well stocked with plants. If there are no plants, you must change the water immediately.

Fishes will eat a variety of foods. An important consideration is to have the food in small particles. The big pieces of food will lie uneaten at the bottom of the aquarium and spoil. Many kinds of prepared dried foods may be used as a standard diet, but to get the most out of your fishes some fresh foods must be given such as: lean meat, liver, yolk of hard boiled egg, oysters and clams. Let me remind you that only small amounts of food should be given and this must

be prepared so that the fishes are able to take it easily. Fishes need their vitamins just as much as land animals. Some of them will live a long time on dried foods alone, but they will rarely produce young on a restricted diet.

It is not difficult to meet these requirements but it calls for a great deal of common sense and patience.

One of the most important things to remember about keeping tropical fishes is that they originally have come to us from warm countries. This means that they must be kept warm. Most people have good luck in keeping tropical fishes during the summer but receive a terrible shock some morning after a frosty night, when they discover their pets no longer showing any interest in life. Never allow the water in the aquarium to fall below sixty degrees. On cold nights throw a blanket over the aquarium before retiring. There will be little loss in temperature when this is done. Tropical fishes as you might expect can stand high temperatures. I have caught tropical fishes in Mexico where the water was 97 degrees and this only in the month of May. By experiment it has been found that it is not safe to have the temperature over a hundred. The most comfortable temperature is 80 degrees the year around. If this is kept up the fishes will continue to breed during the winter months. There are electrical devices on the market to-day which will maintain an even temperature in your aquarium automatically.

Do not allow your tropical fishes to become chilled. If they are not killed outright, they become susceptible to disease. More losses may be attributed to chilling than to any other cause.

The last bit of advice which I will give you is to be sure that you cover your aquarium with a tightly fitting piece of glass. Tropical fishes are notorious jumpers. Unless you do this, your fishes will take to the air, land on the floor, but they will not travel far.

Let me remind you lastly that fishes need fresh air, a warm temperature at all times. They need good food. A good growth of plant life in the aquarium makes for success in tropical fish keeping and breeding.

Provide these essentials and you will be stocking the aquaria of your neighbors.

THE VOCATIONAL USES OF ELEMENTARY HIGH SCHOOL ALGEBRA

BY GEORGE E. HILL,
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During the past few years there has been an increasing tendency to question the value of certain high school subjects. Among the subjects so questioned, mathematics has been very vigorously attacked. Probably the chief reason for this attack has been the break-down of the belief that mathematics has high disciplinary values. This has resulted in a decrease in the relative time-allotment given mathematics in the high school curriculum, as compared with the curriculum of several years ago.

For this reason, that is, the questioning of the value of mathematics, the present study was undertaken. Before any improvement can be made in this field a critical evaluation of the courses now being offered must be made. This can be done only in the light of the aims proposed for these mathematics courses. Three types of values are proposed for these courses: (1) the practical or utilitarian, (2) the disciplinary, and (3) the cultural. This investigation is concerned with determining the practical value of elementary high school algebra, and, more specifically, its value as a vocational tool.

The study being an evaluation of algebra as it is now taught, the first step was to determine what algebra is taught in the elementary course. To this end seventeen algebra text books and courses of study were analyzed and the topics most frequently taught were used as the basis for this survey. The sixteen topics or concepts of algebra most usually taught are:

1. Literal numbers
2. Simple linear equations and formulas
3. Positive and negative numbers
4. Addition and subtraction of algebraic quantities
5. Simple exponents and powers
6. Multiplication and division of algebraic quantities
7. Literal fractions
8. Fractional equations and formulas
9. The statistical graph
10. The functional graph
11. Solution of simultaneous linear equations algebraically
12. Solution of simultaneous linear equations graphically
13. Ratio, proportion, and variation
14. Factoring and special products
15. Simple quadratic equations

16. Square roots and radicals

These sixteen concepts, with examples, were arranged in the form of a check list questionnaire. Each person to whom this questionnaire was sent was asked to check each concept first, as to the number of times he had used it in his work during the past month, and second, as to whether he thought it "very useful," "useful," "of little use," or "of no use" to him in his work. The questionnaire also asked whether the respondent would require all students to study algebra and, if not, whom he would so require.

These questionnaires were sent to 650 college graduates and to 500 high school graduates, most of whom had not gone to college, and none of whom had been graduated from college. Of these 1,150 sent out, 470, or 41 per cent, were returned and used.

The respondents were divided into seven groups according to their occupations—professional, agricultural, household arts, trades, commercial and industrial, fine arts, and public service. Of these, over 80 per cent were either in the professional or commercial-industrial groups. Within these seven main groups there were thirty-eight different occupations represented.

The uses of algebra for each group and sub-group were summarized and the concepts deemed "relatively essential" for the work of each vocation determined. The standards used to determine the essentiality of the different algebraic concepts were rather arbitrary. By means of numerical weights of 1, 2, 3, and 4 for the judgments of usefulness from "of no use" to "very useful" it was possible to determine the combined judgments of each occupational group. In order to be regarded as "relatively essential" to any occupational group a concept must have been used on the average at least once a month by that group and judged as "useful." If, however, the concept was reported as used on the average more than twice a month but judged "of little use" it was regarded as relatively essential.

It is important to note that the results obtained were determined by these arbitrary standards and that the professional, household arts, and commercial-industrial groups were the only ones large enough to give reliable results.

Summary and Conclusions

It seems that five vocations—professional engineers, science teachers, scientific research workers, business and industrial research workers, and equipment engineers—find all or practically all of the algebraic concepts relatively essential to them as vocational tools.

The remaining thirty-three vocations found different concepts useful to them. In all these thirty-three the following six concepts seemed to be most useful:

1. Literal numbers
2. Linear equations and formulas
3. Positive and negative numbers
4. Addition and subtraction of algebraic quantities
9. The statistical graph
13. Ratio, proportion, and variation

So far as represented by our respondents and measured by our methods, only slightly more than one-third of the algebra taught in the elementary course functions as a vocational tool. The concept of solving simultaneous linear equations graphically was reported as used least of all.

Women engaged as housewives, nurses, and stenographers reported almost no algebra used in their vocations. Those respondents engaged in college teaching, library work, fine arts, public service, and certain technical business pursuits reported the use of slightly more algebra than that represented by the six concepts listed above. Twenty-three of the thirty-eight vocations reported no use of algebra beyond these six concepts.

The fact that 60 per cent of the respondents would have all students required to take algebra seems to indicate that popular opinion is still strongly in favor of requiring the subject. This may be due to faith in its disciplinary values as was indicated by the general tenor of the "remarks" made by the respondents.

Although the technique employed has obvious weaknesses, we believe that it would be profitable to employ it in a more extended survey of the vocational uses of mathematics. It seems especially desirable to test the reliability of the technique experimentally. The desirability of critically evaluating the avocational, cultural, propaedeutic, and disciplinary values of mathematics, as well as the more practical values, seems quite evident.

RATIOS OR CONCRETE NUMBERS? II

By Warren C. Hawthorne,

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In a previous article we discussed the advantages of impressing upon the mind of the student of high school physics that the quantities he meets in nature are not ratios merely but may be looked upon in most cases as concrete numbers; furthermore, that the use of the dimensions involved is a decided advantage in the calculation of results, leading to clarity of thinking.

College physics differs, or should differ at least, from high school physics in that while the latter is informational, the former is analytical. For instance, the pupil should learn in his elementary course as many of the physical units, erg, foot-pound, dyne, calorie, volt, ampers, etc., as he can use. His college course should be more than an extending of this list; it should show him the relation between the different units,—show him that they are all part of a general plan. One way of doing this is to give a little drill occasionally in the manipulation of dimensional equations, using capital letters to represent the units. For instance, to show that $\frac{1}{2}at^2$ represents a space:—the dimensions of a are V/T or LT^{-2}. Multiplying this by T^2 gives L, a distance or length. Or, to prove that the pressure multiplied by the change of volume of a gas represents work:—the dimensions of pressure are F/L^2; of V are L^3. Multiplying these together gives FL, the dimensions of work. That the speed of propagation of a disturbance through an elastic solid or liquid is equal to the square root of the elasticity divided by the density, i.e. $S = L/T = \sqrt{E/D}$, is shown more easily by reducing the dimensions under the radical sign to fundamentals than in any other way.

By the end of his first year of college physics, he should have become convinced that all the units used in physical measurements are reducible to expressions containing only the "fundamental" units of mass, length, and time. Thus, power is the amount of work done in unit of time; $P = W/T$. But $W = F \cdot L = MLT^{-2} \cdot L$ and dividing by T gives ML^2T^{-3}. The use of the electrical units, involving two other dimensions, k and u, will be discussed later.

Psychologically, the notion of force is more fundamental than that of mass, which is really derived from the observation

that different amounts of force are required to give the same acceleration to different bodies. But the use of *mass* as the fundamental and *force* as the derived unit, $F = MA = MLT^{-2}$, leads to a simpler system.

Occasionally we encounter situations that seem perplexing at first sight. Thus, the dimensions of a torque and of work seem to be identical, both being usually given as FL. But we remember that the F and the L in the case of a torque are at right angles to each other. If we were to use the sign of the imaginary to indicate this, writing $\text{Torque} = FLi$, we have a perfectly logical way of distinguishing them. I know of no case where the use of this convention would introduce an inconsistency.

But can the use of dimensional equations really tell us anything we didn't know before? Let us see. Suppose we have tied a stone to a string and whirled it about our head. The tug on the string is obvious, and if we are scientifically minded we shall notice that it varies with the length of the string, the mass of the stone and its velocity. But how? Directly or indirectly? As the first, second or some other power? In other words, what are the exponents of r, m, and v in an expression that shall give us the value of the centrifugal force, F_c? There seems to be no other factor that can affect it. Let us put

$$F_c = k\ m^x\ v^y\ r^z,$$

where x, y, and z may be any numbers, positive or negative, fractional or integral, and k is a factor of proportionality, a pure number of zero dimensions. Now the dimensions on the left must be identical with those on the right. The dimensions of F are MA, or MLT^{-2}, of m is M, of v are LT^{-1}, and of r is L. (Li if we wish to call attention to the fact that r is at right angles to the velocity) The equation we have, then, is

$$MLT^{-2} = M^x(L^y\ T^{-y})\ L^z$$

From this it is evident that $x = 1$, $y = 2$, and $y + z = 1$, whence $z = -1$, and we have $F_c = k\ m\ v^2\ r^{-1}$, a result which agrees with quantitative experiment.

It is equally easy and interesting to write out the dimensional equation of the simple pendulum, remembering of course that g is an acceleration with the dimensions LT^{-2}, and prove that the right hand member reduces to T. For more involved cases, in which the method is a decided short cut to the formation of an equation showing the relation of certain physical constants to the properties of a substance, see Edser's Physics for Advanced Students: p.346, Period of Oscillation of a Drop; p.477,

Retarding Force Due to Waves Produced by a Body Moving Through a Liquid; p.489, Critical Velocity of a Liquid Moving Through a Tube; p.527, Viscous Drag of a Liquid on a Body Moving Through It.

Of course this method does not give us any clue as to the magnitude of the factor of proportionality which is always present. This must be obtained by experiment or by mathematical reasoning of another sort, but the form of the equation as given by the variables and their exponents is always worth knowing, and often all that we need to know, in that it suggests the kind of an experiment that will give us the value of k.

Heat, we were assured by Mayer, Rumford, Joule, et al., is energy, and such a quantitative relation exists between heat and mechanical energy that we may state that J ergs of work equals H calories of heat. But are they really of the same nature (dimensions), or is the relation existing between them somewhat like that which exists between fifteen cents and a package of Luckies? Well, a calorie is that amount of *something* that raises the temperature of one gram of water one degree. so that the dimensions of a quantity of heat must be written $h\text{M}\cdot n\text{T}$, where h and n represent pure numbers, and T stands for unit quantity of this something that is changed when the temperature of one gram of water is raised one degree. The dimensional equation between mechanical energy and heat becomes then, $\frac{1}{2}\text{MV}^2 = hn\text{MT}$, whence it is perfectly evident that T (temperature) has the dimensions V^2, and thermo-dynamic consideration of gases makes it evident that this velocity is the velocity of the molecules. No temperature at all or absolute zero now has a meaning that it couldn't have without this conception: it is simply that condition of a body wherein all molecular motion has ceased. On the other hand, the enormous temperatures measured in the stars, given sometimes as millions of degrees, is only the astronomers' method of expressing the mean velocities of the molecules.

Much as we have learned about electricity in the last hundred years, a similar problem there (and in magnetism) remains unsolved. The force between two quantities, q and q', of static electricity is $f = qq'r^{-2}/k$, whence $q = \sqrt{kfr^2}$, and the dimensions of quantity of electricity turn out to be $\text{Q} = \text{K}^{\frac{1}{2}}\ \text{M}^{\frac{1}{2}}\ \text{L}^{\frac{3}{2}}\ \text{T}^{-1}$, K being of unknown dimensions, but indicating some property of the medium. This leaves us up in the air (or up in the ether,

rather) with two unknowns, Q and K. Similarly, the dimensions of quantity of magnetism are $M = \sqrt{u\ F\ L^2}, = u^{\frac{1}{2}}\ M^{\frac{1}{2}}\ L^{\frac{3}{2}}\ T^{-1}$; u, the magnetic permeability of the medium, again being of unknown dimensions.

In spite of this, however, we may get some very interesting results from a study of the dimensions of electrical quantities. In neither the electrostatic nor the electro-magnetic system are the units of quantity reducible to a length; nor is the expression for potential difference reducible to a force, however much we may talk about "a *pressure* of 110 volts." Actually, in the electrostatic system, it is $E = L^{\frac{1}{2}}\ M^{\frac{1}{2}}\ T^{-1} K^{-\frac{1}{2}}$. Multiplying this by the dimensions of quantity, we get $M\ L^2\ T^{-2}$, or $M\ V^2$, clearly of the dimensions of Work. Similarly, in the electromagnetic system we have $Q = L^{\frac{1}{2}}\ M^{\frac{1}{2}}\ U^{-\frac{1}{2}}$ and $E = L^{\frac{3}{2}}\ M^{\frac{1}{2}}\ U^{\frac{1}{2}}\ T^{-2}$. Again, on multiplying these together, we get dimensions of work, as we are accustomed to when we glibly rattle off, "Coulombs times volts gives joules."

Every one is familiar, of course, with the curious relation between the units in the two systems. Dividing the electrostatic unit of quantity by the electro-magnetic, we get a speed. When we actually measure the same quantity of electricity, first by the electromagnetic units and then by the electrostatic and find the ratio of the numerical results, the quantity turns out to be the speed of light. It was this discovery that led to the famous Maxwell Equations, proving that light must be looked upon as an electro-magnetic disturbance in the ether, and suggesting the possibility of propagating artificially made "electric waves," a suggestion that was made concrete later by the brilliant work of Marconi.

USE FOUND FOR BERATED PESTS

English sparrow and European starling, much berated as pests of the first order, have at least one use in the world, says Dr. Thomas E. Winecoff of the Pennsylvania Game Commission, in a report to the headquarters of the National Association of Audubon Societies here. They are destroyers of a much worse pest, the Japanese beetle.

Not many birds will eat Japanese beetles, Dr. Winecoff says, but sparrow and starling are joined in their attack by two of our commonest song-birds, themselves occasionally looked upon as nuisances by orchardists: robin and purple grackle. And down on the ground an introduced game bird, the ring-necked pheasant, lends a helping hand, or rather beak, in the good work of beetle destruction.—Science Service.

THE OVERVIEW OF THE UNIT IN PHYSICS*

BY CLIFFORD HOLLEY,
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In his address at the installation of the Harvard chapter of Sigma Xi, President Stewart stated, "Science has a definite appeal for its own sake. It has a distinct aesthetic value. It has a challenge to the human mind that will always attract those of high intellectual ability. . . . The influence of science will not depend entirely upon its laudation by the public, nor upon its continued growth and mastery over nature. Additional prestige will be obtained from the fact that, in all fields of science, students are attempting to use the scientific method in creactive scholarship."[1]

In our teaching we are not so much concerned with attracting students with high intellectual ability to the pursuit of the study of physics, as we are in developing a scientific method, which will apply not only to the teaching of science, but also to other subjects. Since his subject itself offers such a fine example of a method in science, the teacher of physics might be expected to be among the first to apply a scientific method to its teaching, unless perchance, he assumes the view of a certain college professor, that if one knows physics he can teach the subject.

Two of the specific aims of science teaching commonly stated are: (1) To impart a fund of useful information, and (2) to develop skill in scientific thinking. It is to be regretted that teachers often assume that the teaching of the first necessarily includes the acquisition of the second. Physics is said to be the science of common sense, but the chief aim of the teacher is to train the individual so that he can apply common sense where the untrained individual would be unable to apply it. Such training the teacher attempts to give through the cultivation of the scientific attitude.

It is evident that neither physics nor any other science can really be taught as a series of individual facts. True, it is conceivable that there can be imparted a fund of

*Read before the Physics Section of the Central Association of Science and Mathematics Teachers, November 1931.

[1]Sigma Xi Quarterly, p. 88, September, 1931.

useful information, which an occasional student may analyze to determine what parts of such information point to a single, large aspect of physics. However, for the majority of the class, this information remains as a mass of individual facts.

One of the more recent examples of the scientific method in secondary teaching is that of organizing the material of a given course into units of instruction. Many teachers have become interested in this method within the last few years and have been developing various courses into units, with perhaps as many types of units in a given subject as there have been teachers organizing the course. In the interest of the exchange of ideas it may be profitable to discuss and illustrate one phase of the teaching of a unit in physics, namely, the *overview of the unit.*

The term *overview* is used here in the same sense as have the terms *presentation* and *preview* been used in previous discussions. The overview presents to the class in a very few minutes the significant aspects of the unit to be studied. Its relation to the unit is somewhat similar to that which the science survey courses, as now offered by many colleges and universities, bear to the various science courses. The purpose of the overview may be considered as three fold: (1) It gives a complete survey of the principles of the unit; (2) it orients the pupil so that he may know at any time the purpose of studying any assigned assimilative material and its contribution to the understanding of some fundamental principle of the unit; (3) it serves to stimulate interest and desire for detailed investigation. Before the overview can be prepared the unit itself must first be carefully set up according to whatever criteria are used to determine a unit. The unit having been selected the overview can best be prepared if the unit is completely analyzed. Such unit analysis requires stating in sentence form (1) the unit understanding, or learning objective, (2) the elements of the unit, and (3) the sub-elements of the unit. Such an analysis may be illustrated as follows:

THE ACCOMPLISHMENT OF WORK

Analysis of the Unit

Unit Understanding: Work is accomplished by expending energy

to overcome forces, that resist the motion of a body. Man utilizes machines to enable him to do work more conveniently or to do work that would otherwise be impossible. He never gets from a machine more energy than he expends on it.

A. To do work something must be accomplished.

1. To do work a force must move a body through a distance.
2. Work is measured by the product of the force times the distance moved.
3. Any unit of force may be used with any unit of distance to give a unit of work.
4. Common units of work are foot-pound, dyne-centimeter (erg), and joule.

B. Machines are used to vary the direction or magnitude of a force or to transform energy.

1. By the use of a machine a small force can be transformed into a larger force, or a large force into a smaller force.
2. If the force is transformed into a larger one there is a loss in speed, while if it is transformed into a smaller force there is a gain in speed.
3. A machine can be used to change the direction of a force without producing any change in its size.
4. By the use of a machine energy in one form can be transformed into energy in some other form.
5. Any complex machine can be resolved into a number of simple machines.

C. Energy can be neither created nor destroyed.

1. When work is done on a body the same amount of energy always appears in some form.
2. The principle of conservation of energy enables us to determine easily the mechanical advantage of a machine in terms of its dimensions.
3. Energy is classified in many forms, but this is for convenience only.
4. Mechanical energy is measured by the work done, or by the mass and velocity of a moving body.
5. The total amount of energy in the universe does not change with time.

D. Some energy is always wasted when work is done through the agency of a machine.

1. Much work is wasted in overcoming friction in a machine.
2. The energy lost appears in the form of heat.
3. The amount of energy available for man's use is constantly decreasing.
4. The cause of friction is the interlocking of small projections on the two surfaces in contact.
5. Friction can be reduced, but never eliminated.
6. Friction is a help as well as a hindrance to man.
7. Friction increases rapidly with speed.
8. The efficiency of a machine is determined by the amount of work lost through friction.

After the above analysis has been made the teacher has definitely in mind just what is to be taught in the unit, and can now prepare the overview. This has, as indicated above, for its purpose a survey of the principles of the unit, and their interrelations. This needs to be carefully organized so that it can be presented orally by the teacher in a time of not more than fifteen min-

utes. If too long a time is required, the student is not able to organize all the ideas in his own mind and hence does not see the entire unit as focusing simply on one big understanding. Furthermore, his interest cannot be maintained at a high level over too long a period of time. Demonstrations are to be avoided since the student becomes so interested in watching experimental manipulation that he loses sight of the organization of principles. For the same reason the number of illustrations used should be small. If carefully thought out the overview for nearly any unit can be delivered in the time indicated. It is not necessary that any statments be proved. Many questions will occur to the students, but these need not be considered by the teacher at this time, since the purpose of the assimilative material of the unit is to prove, clarify and apply the material outlined in the overview. The following material represents an overview of the unit outlined above.

The Accomplishment of Work[2]

An Overview of the Unit

The accomplishment of work is perhaps the most important thing in the world. All life depends on work. A moment's reflection shows that all the comforts and all the necessities of life are the results of work done by some one or some thing. A tree grows only because energy is being constantly spent on it, man and other animals store up energy through the eating of food, and an automobile runs by using the energy stored up in the gasoline.

Our usual reaction to the word *work* is a feeling that something is to be done, or has been done, involving some mental or physical activity. When one pushes a lawn mower, walks to school, or studies his lesson, he is *working*, according to this conception. But in the study of physics we consider that work is done only when some force moves the body, on which it acts, through some distance. In the scientific sense, then, mental activity is not considered as work.

Since a force must move through a distance in order that work may be done, it becomes evident that the amount of work accomplished by a given force will depend on the size of that force and on the distance through which it acts. To get a measure of the work done each of these two factors must be measured. Since both force and distance can be measured in many different units, it is possible to measure the work done in many different units.

It often happens that when a force acts on a body to move it, or parts of it with respect to other parts, the body will be in such a position, or in such a state, that it will do work on some other body. The first body is then said to possess *energy*. We can determine the amount of energy possessed by a body by finding the amount of work it is capable of doing in expending that energy. Many types of energy, such as electrical energy, heat energy, and mechanical energy, are used in the accomplishment of work. In this unit we shall be concerned with mechanical energy only, and

[2]"Mastery Units in Physics," Clifford Holley and Vergil C. Lohr, p. 195, Lippincott.

in later units we shall study other types of energy. A lifted weight possesses mechanical energy, the amount of which is determined by the mass of the body and the height to which it is lifted. If allowed to fall it can be made to lift a second weight, and thus do work. A moving body cannot be stopped unless a force is applied through some distance, and thus work done. The greater the speed of the body and the greater the mass, the greater the amount of energy it possesses. An automobile moving with a speed of 30 miles per hour can be stopped much more easily than can a train moving with the same speed.

In making our measurements in the study of work we are interested not only in the force applied and the distance through which it acts, but also in the time required to accomplish a certain amount of work. A given quantity of energy may be expended in a few seconds or in many hours. A man may transfer a pile of bricks from the sidewalk to the top of a building by carrying them up a few at a time, or he may place them on an elevator and take them up all at one time. The work accomplished is the same in the two cases, but in the latter case it is done much more quickly. If one knows how many units of work are done in one unit of time by a machine, or by any agent, and the time for which it operates, he can compute easily the total amount of work done. The speed with which work may be accomplished is an important factor in modern industry.

From the earliest times man has resorted to mechanical devices to aid him in doing his work. By such means he is often able to do a bit of work that would be impossible otherwise, and usually certain important advantages are to be gained. By the use of a machine, a small force may be applied to overcome a large resisting force, a force may be applied in one direction to overcome a resisting force in some other direction, or there may be a gain in speed. Although advantages are to be gained in the use of a machine, the work done by it can never be quite so great as the energy supplied to it. Even though there were no friction to be overcome in a machine there could be no gain in the work accomplished through its use, for nature demands that an equivalent amount of energy shall be expended for every bit of work done. It might seem that through the use of a gasoline motor man can drive an automobile without doing much work. However, in doing this he utilizes the energy from the gasoline.

Some energy is always lost through overcoming friction when a machine of any kind is used in doing work. The problem of decreasing this loss is one that commands much attention."

INITIATIVE PROJECTS

By Arthur W. Schmidt,

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In order to impress more thoroughly upon the minds of high school freshmen that the study of General Science is an attempt to familiarize them with the organization and functioning of the things, processes and phenomena that they find a part of their universal environment we have introduced in our teaching methods a type of individual research problems which we term "initiative projects." The projects are designed to reveal the students' initiative

ability in carrying on scientific investigations and in making scientifically accurate interpretations from material facts.

The projects are assigned to the students at the beginning of the second semester, or when they have acquired a sufficient background in scientific study to enable them to successfully carry on the investigations. They serve as a practical supplement to the class-room course. Each project includes four activities: first, a thorough study of the topic selected for investigation; second, the preparation of a descriptive essay explaining the subject investigated; third, a sufficient number of pictures, drawings, diagrams, charts, maps, graphs, etc., to satisfactorily illustrate references in the essay; and fourth, a collection of samples or specimens, or the preparation of apparatus to illustrate concretely that particular phenomenon, process, industry or activity investigated.

The projects are usually prepared in a form suitable for a school exhibit, thereby the better enabling all the students to examine each others' work, and in so doing to become more familiar with the extent of the field of topics covered. This practice also adds immensely to the interest in science study in general through the incentive of a friendly and lively competition. The first form in which a project may be prepared is known as the "poster" type, the second as the "booklet" type, the third as the "combined poster" type, and the fourth as the "combined booklet" type. The following paragraphs describe a project of the third type:

AN INITIATIVE PROJECT ON GOLD MINING

Living in a town in which the basic industry is gold mining, a town located immediately over the world's greatest gold mine, and having, throughout his childhood, heard his parents and friends discuss various phases of the mining industry, this young student decided to interest himself a little further in the activity that supports his home town. With the knowledge and information gained in the study of General Science he would try to find out how some of the mechanical and other scientific principles of which he had learned, apply in the processes of mining and refining of the precious metal.

The first step in his investigation was to make several visits to different parts of the company plants and there to make observations. Then he collected articles from various publications on mining activities and studied reference books obtained from the school library. Scoring down the reference materials and selecting only the information that is of immediate interest in his study is no small task for a high school freshman. Not being able to gain admission to the underground mining activities he had to obtain the specimens of ore that he needed from a responsible person in the employ of the company.

The second step in his research study was to outline his plan of procedure and his essay on one of the mimeographed forms provided for that purpose. The ore samples he obtained were samples of arsenopyrite, quartz, and of chlorite schist, each containing minute particles of free gold. The pictures he selected were chosen to convey an idea of the important operations involved in the gold mining process. He had pictures of the open-cut, blasting in an open-pit, sill-floor of a shrinkage stope, chute pulling, block-holing, outside view of a stamp mill, two views of the cam-floor of a stamp mill, and two views of the vat-floor of a cyanide plant.

His essay was outlined to include discussion of the following topics: A brief historic statement of the early mining activities in Lead and in the neighboring towns of Deadwood, Central, Terry and Trojan. Sinking of shafts. Drifting underground. Blocking out the ore. A shrinkage stope, mining and block-holing. Timber lines. A square-set timbered stope. Chutes and chute pulling. Underground transportation of ore. Ore-bins and hoisting of ore. Filling of empty stopes from the open-pit. Crushing underground. Milling, briefly. The cyanide plant, briefly. The slime plant, briefly. Refining of amalgam and precipitates in the assay office, briefly. The value of gold mined and its disposition on the market.

The final step in the preparation of his project was to recheck his information, to select only that which was essential and to reject the other. Before completing the essay he had it corrected for errors in grammar and in English by his English teacher, and then mounted it with the pic-

tures and the samples on the prescribed placard in a neat arrangement. This "combined poster type" of an initiative project was then examined by his Science instructor and stored away, or exhibited in the class-room until time for the annual school exhibit in the gymnasium.

Through this original study this student had an opportunity to follow his own interests, to make a personal investigation of an activity vital to civilized human existence; to collect what he considered important in carrying on his investigation and study; to organize his materials and knowledge; to present them for criticism; to recheck, reconsider, and evaluate the information he finally submitted in his essay; to adapt himself to acquiring habits of scientific procedure; and, through his own creative efforts, to contribute instructional materials to his class-mates.

TEACHING VERBAL PROBLEMS IN FIRST YEAR ALGEBRA

BY GEORGE E. HAWKINS,
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To pupils studying algebra the solving of verbal problems invariably causes more or less difficulty, and the topic continues to be a subject for discussion among teachers. The process involves several steps, the first of which is intensive reading. Without this ability the pupil cannot make satisfactory progress. The solution requires also the ability to express in algebraic symbols the words and phrases of the problem, the ability to analyze the problem and organize the facts, to recognize the relationship involved, to form the necessary equations, and to solve them.

The writer attempted, through an experimental study, to determine the effectiveness of considerable practice material devised to help develop two of these abilities on success in problem solving. Practice exercises giving specific practice in translating the English expressions into algebraic symbols and in analyzing problems were used with pupils in one section of an algebra class. The type of material used together with the results seem to throw some light on the topic "verbal problems."

Two groups of freshmen were used in the study. For convenience in distinguishing the two groups the control

group is labeled section I and the experimental group as section II. To compare the abilities of the pupils in the two sections, an examination was made of the scores received on the following tests: The Otis Self-Administering Tests on Mental Ability, the Breslich-Reavis Diagnostic Tests in the Fundamental Operations of Arithmetic and in Problem Solving, and the Breslich Algebra Survey Test, first semester. The median and average scores for the two sections on the various tests were very close, and neither group seemed to have any particular advantage over the other so far as ability is concerned.

Both groups used the same text, and the experimental work was carried on while the classes were solving verbal problems in the chapters on Simple, Simultaneous, and Quadratic Equations. In their earlier mathematical training all of the pupils had had considerable practice in solving verbal problems arithmetically but had had practically no experience in solving them algebraically except substituting in formulas for the areas and volumes of various figures and solving the equations involved. Before attempting to solve verbal problems all of the pupils had some practice in translating English phrases into algebraic symbols. Such exercises as the following were used:

> A number decreased by 85 is equal to 99.
> The base of a triangle exceeds the altitude by 4 inches.

Then, following the instruction from the teacher the pupils in section I proceeded to solve the assigned problems in the text, getting some additional help from the illustrative examples used there.

The pupils in section II used the same material in the textbook, but in addition to that the instructor furnished them with additional practice material especially prepared to give practice in symbolic notation and aid in analyzing the problems. During the time the class was solving distance problems a mimeographed sheet of exercises similar to the following was handed to each pupil:

1. An automobile tourist sets out on a 400 mile trip. Express the time required if he goes at the rate of:

   a. 40 mi. an hour; c. (r-10) mi. an hour;
   b. *m* mi. an hour; d. (2r-3) mi. an hour.

2. Two trains leave Chicago at the same time, one eastbound, the other westbound. The eastbound train travels 10 mi. less in an hour than the westbound train. Express algebraically:

   a. the rate of each;

b. the distance traveled by each in 4 hours;
c. the fact that the trains are 440 miles apart at the end of 4 hours.

The following exercises taken from various types of problems illustrate further the type of material used:

1. A farmer has two kinds of seed—clover seed and bluegrass seed. If he has 100 lb. of the two kinds together, express algebraically:
a. the number of pounds of clover seed if there are n pounds of bluegrass seed;
b. the value of the clover seed (n pounds) at 20c a pound.
c. the value of the bluegrass seed at 15c a pound.
d. State by an equation that the value of both kinds together was $19.

2. A druggist added a certain amount (x ounces) of water to 50 ounces of a 25% mixture of alcohol and water. The new solution was then a 20% mixture. Complete:
a. He then had ——— oz. of mixture.
b. The original solution contained ——— oz. of alcohol.
c. The new mixture contained ——— oz. of alcohol.
d. Since the amount of alcohol remains the same and you have represented it by two different expressions, form an equation from these two expressions.
e. If you were to solve this equation and get a value for x, what would it represent?

3. If a telegram of 16 words costs 57c and one of 11 words costs 47c, what is the charge for the first 10 words in a message and what is the charge for each additional word over 10.
a. Let x = no. cents the first 10 words cost
y = no. cents each additional word costs
The 16 word telegram contained —— words more than 10, each of which cost y cents. These cost —— cents. The first 10 words cost x cents. Then ——— = 57, is one equation.
b. The second equation is ———.

Exercises of a similar nature were used throughout the study of verbal problems. The class procedure varied somewhat on different days, but one commonly used was for the instructor to ask the pupils to put the sheet of exercises in their notebooks with their other class work, then to write the answers to the exercises on the mimeographed sheet. Usually about ten minutes of one period was spent by the class on these exercises, five minutes for writing the answers and five minutes for discussion. The pupils carried on the discussion except in case of an exercise that caused difficulty. In that case the instructor explained the exercise fully. Frequently half of the exercises on one page were used one day and the remainder the next. Thus this additional practice was distributed, and only a few minutes of any one period were used for that purpose. Two results of this practice was evident to the instructor. The pupils seemed to have less difficulty with the problems in

the textbook than the pupils in section I, and the class was able to do the same amount of work from the textbook in the same length of time as the other class.

As an aid in determining whether this additional practice enabled the pupils who did it to form the equations needed in the solution of problems more successfully, the following test of twelve verbal problems in which the pupils were asked to form the equations was given to each group before they began the work on simple equations and then again after they had completed the unit on quadratic equations.

Test I—Test on Verbal Problems

Form the equations needed in the solution of the following problems. Do not solve the equations. Read the illustrative example and its solution before starting on the problems.

Illustration

Bob and Ned sold apples from house to house. They started out with 12 bushels. Bob sold 1½ bushels less than Ned, and they had 1 bushel left when they returned home. How many bushels did each boy sell?

Solution:

Let n = number bushels Ned sold
then $n - 1\frac{1}{2}$ = number bushels Bob sold
$n + n - 1\frac{1}{2} + 1$ = total number of bushels
$n + n - 1\frac{1}{2} + 1 = 12$, the desired equation.

1. If I add 23 to a certain number, the sum is 51. What is the number?
2. Separate 56 into three parts such that the second is four times the first, and the third is half the second.
3. A man has 48 rods of wire fence. He wants to use all of it to enclose a rectangular plot of ground that will be three times as long as it is wide. Find the length and width of the plot.
4. One pipe can fill a tank in 10 hours. Another can fill it in 14 hours. How long will it take both to fill it?
5. How much water must be added to a barrel of vinegar which is 85 per cent pure to reduce the strength to 50 per cent?
6. If six trips of a small truck and 2 trips of a large truck will deliver 23 tons of coal, while 1 trip of the smaller truck and 2 trips of the larger truck will deliver 13 tons, find the capacity of each truck.
7. If the hypotenuse of a right triangle is 15 inches, and the sum of the other two sides is 21 inches, what is the length of each of these sides?
8. A man wishes to invest $4500., part at 4 per cent and part at 7 per cent so as to obtain an average of 6 per cent on $4500. How much shall he invest at each rate?
9. Two trains start at the same time from towns 296 miles apart and meet in four hours. If the rate of one is 6 miles an hour less than the rate of the other, what is the rate of each train?
10. A clothier knows that he can sell a large number of suits "priced in the thirties." How much can he afford to pay for a suit if he wishes to sell it for $37.75 and gain 18 per cent of the cost?
11. A foreman received the following order: "Please design for us an open tin box to contain 700 cubic inches. It must be 4 inches longer than it is wide and must be 5 inches high." What should be the dimensions of the rectangle from which the box may be made?

12. George Barclay wants to make a cupboard with three shelves (4 with the bottom) each 1 inch thick. Each space should be 3 inches less than the one below it, and the inside measure of the cupboard must be 49 inches. How far from the bottom should he place the first shelf?

By computing the percentage of correct responses made by each group on both the final test and on the pretest, then substracting, one gets a measure (in percentage) of the learning that has taken place. When the scores for these two classes were computed, it was found that the gain measured in per cent, of the experimental group was 5.8 points greater than the gain of the other group. The average and median scores of the experimental group were each one higher on the final test than those of the other group, while on the pretest the average and median scores for both groups were the same. Thus it seems that the additional practice given the one group had a favorable influence on their improvement in ability to form equations in the solution of verbal problems.

In addition to the test of twelve problems discussed above, the test below consisting of seventeen exercises in translating English expressions into algebraic symbols was given to both groups at the end of the work on verbal problems.

TEST II

Express in algebraic symbols:

Illustration: The square of the sum of two numbers, $(a + b)^2$

1. Three times the difference of two numbers.
2. The perimeter of a rectangle *a* units long and *b* units wide.
3. The area of a rectangle *a* units long and *b* units wide.
4. The perimeter of a square whose side is *s* units.
5. Three more than a number.
6. Three times the product of two numbers.
7. 4% of *n* dollars.
8. The difference of the squares of two numbers.
9. The distance traveled in *n* hours at 40 mi. per hour.
10. 3% of *x* plus 4% of *b*.
11. 3 more than *x* plus 4 more than *b*.
12. Three less than one third of a number.
13. Three times the sum of two numbers.
14. The difference of the squares of *r* and *b*.
15. The length in feet of a fence around a rectangular lot *w* feet wide and *l* yards long.
16. Six more than two thirds of a number.
17. A can of milk holds *m* pounds of milk containing 3% butter fat, and a second can holds *c* pounds of cream testing 50% butter fat. How many pounds of butter fat are there in both cans?

On this test the average and median scores for both groups were the same. These results are interesting for

they seem to conflict with those of the first test. But when one considers the difference in the nature of the steps involved in the two tests, the second makes a further explanation to the problem. From their experiences and practice in solving verbal problems, the pupils in section I got sufficient practice in translating English expressions into algebraic symbols to enable them to do it as successfully in a test as the pupils in the other section who had had more practice. Hence from that standpoint alone the additional work was not justified. But the test of twelve problems involved other steps also, one of which was analyzing problems. The pupils in section II had specific training and help with this step in the additional work they did and were able to form the equations for the verbal problems somewhat more successfully than the pupils in the other section.

The study as a whole seems to confirm the belief that considerable practice in problem analysis is an aid to the pupil in solving verbal problems. Exercises in which problems are analyzed or partially analyzed for the pupil distributed through the lists of verbal problems make progress less difficult for the pupil, furnish him a technique of procedure, are an aid in helping him to attack other problems, and as a result, enable him to solve verbal problems more successfully after the assigned work is completed.

BETTER RADIO RECEPTION AFTER JUNE 22

Reception from radio broadcasting stations should be better after June 22.

The improvement will come, not from any change in the number of spots on the sun, but from additional perfection of apparatus and methods here on earth. For after June 22 the Federal Radio Commission will require that broadcasting stations maintain their allotted frequency with ten times the accuracy now specified.

The new regulation, which was adopted by the Commission June 22, 1931, to go in effect one year after that date, provides that all broadcasting stations shall maintain their assigned frequency between the limits of 50 cycles above or below the channel allocated to them. Under the present law a 500-cycle deviation from the assigned frequency is allowed.

This means that under the present law the station's frequency may change as much as one kilocycle but the new regulation limits this permissible change to one-tenth kilocycle, the Commercial Standards Monthly, publication of the U. S. Bureau of Standards, explains.

A NEW MEASURE OF CENTRAL TENDENCY

By Julian M. Blair,

University of Colorado, Boulder, Colo.

The determination of central tendencies arises from a need of some quantity which is, at least to some degree, representative of a series of numbers or scores. The three most common measures are the arithmetical mean, the median, and the mode. The arithmetical mean and the median are widely used in educational statistics. Too frequently both are determined for a given set of data and that one which gives the most favorable results is reported.

The arithmetical mean (often incorrectly designated simply as the mean or average) is the sum of the scores divided by the number. It is that value which a group of scores assumes if we subtract from the higher and add to the lower until a common level is attained. If in a given class there are one or more very low scores the level of the whole is unduly reduced in order to bring these extremes to the common level. We can consider a series of scores as a series of equal weights fastened to a bar. The arithmetical mean is analogous to the point where the fulcrum must be placed in order to balance the bar. Quite a number of good scores somewhat above the average may be counterbalanced by a single poor score at the extreme end of the bar.

The median on the other hand, is a single score from the center of the group which is supposed, because of its position, to be representative of the whole. Some authors make a distinction between mid-measure and median. Where such a distinction is made mid-measure is defined as that score above and below which there are equal numbers of scores. The median is in this case defined as the central score determined not from the actual scores but from a frequency table based upon them. These two measures are identical if the steps are sufficiently small. In using the median we assume that one child can represent the whole; i.e. there is an average child.

The mode is that score which occurs most frequently. It is the least reliable measure of central tendency and is very rarely used as a norm in education. It is often used in commerce. A merchant in selecting his stock does not

order most shoes of the average size for there is little demand for a size which is the average of the size that a man wears and that which a woman wears. Larger numbers are purchased in the modal sizes.

In the case of an ideal or normal distribution the three measures of central tendency have the same value, and either is to a large degree representative of the whole series of scores. But when these measures are applied to actual groups of scores they may be very different and are often misleading.

Let us consider the implications of these measures when applied to a small group of pupils. The generalizations which we shall make on the basis of this group will be valid but perhaps to a different degree for a larger group.

In order to show how deceptive the arithmetical mean may be let us consider a class of four pupils whose grades on a given test are 75, 84, 85, and 90. The arithmetical mean of these scores, 83.5, might be indicative of effective teaching. Let us assume, however, that there is in the class a fifth pupil devoid of ability whose grade is 10. The presence of this pupil reduces the arithmetical mean to 68.8, which would be indicative of ineffective teaching. The presence of low scores in a series of grades should to some degree be reflected in the norm for that group, but the arithmetical mean is overwhelmingly affected by them. Very low scores are often due to illness, absence of ability or other factors which the teacher could not have overcome. To use the mean in any way to evaluate the work of a teacher may be very unjust. When the arithmetical means of grades are determined the effect of the extremes is more often downward than upward. A dull pupil may be 70 points below the general trend, but an able pupil cannot be more than 30 points above the normal.

In the series of grades previously mentioned the median would not be so greatly affected by the extreme score. It would change from 84.5 for four pupils to 84 for five. This is probably a fairer measure of the accomplishment of this group. But let us consider how nearly typical of the group is the student whose grade is 84. The nearest grades on either side of this are 75 and 85. If this individual whose score is the median had made a score of 75 that would also

have been the median for the group. If he had made any score between 75-85 inclusive that score would have been the median. Since the median depends within too wide limits upon the score which some individual happens to make it is unreliable. The arithmetical mean is more reliable but undue emphasis upon extremes makes its value questionable.

The inferiority of the mode is apparent when we consider the original group of grades, 75, 84, 85, and 90. If the fifth student happens to make either of these scores that score is the mode.

The author suggests that the arithmetical mean of the middle fifty per cent of the scores be used as the measure of central tendency. It is further suggested, purely as a convention, that where fifty per cent of the number of scores is not a whole number the measure be based upon the next largest whole number. This is a measure of what the normal pupil is accomplishing. It has the reliability of the mean. It reflects, but not unduly, the presence of exceptional pupils for the numbers of such scores affects the determination of the middle fifty per cent.

Greene and Jorgenson and other recent authors recommend that the median which is obtained from a frequency table is of more value than a mid-score obtained directly from the scores. This suggestion is a vague step in the direction indicated by this proposal. But it is a variable measure depending upon the magnitude of the step interval in the frequency table. If the step interval is sufficiently small the value determined from a frequency table is identical with the mid-score and therefore equally unreliable; for larger step intervals the assumption that the grades are uniformly distributed in that interval may be misleading.

The following table summarizes the magnitudes of these measures for the two sets of scores:

TABLE 1

Scores	Arithmetical Mean	Median	Arithmetical mean of middle 50%
75, 84, 85, 90.	83.5	84.5	84.5
10, 75, 84, 85, 90.	68.8	84.0	81.3

These different measures were applied to the two skewed distributions shown in table 2. Table 3 shows the magnitudes of these measures for those distributions.

TABLE 2

Score	Positively Skewed Frequency	Negatively Skewed Frequency
20	2	1
25	3	1
30	3	1
35	5	2
40	10	2
45	9	2
50	6	2
55	5	2
60	4	2
65	3	3
70	3	5
75	3	6
80	2	10
85	2	8
90	2	1

TABLE 3

	Mode	Median	Arithmetical mean of middle 50%	Arithmetical Mean
Positively Skewed	42.5	49.44	50.62	53.14
Negatively Skewed	82.5	76.25	74.60	69.37

SCIENCE QUESTIONS

June, 1932

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

THE MECHANISM OF OXIDATION

606. *Proposed by Carl G. Campbell, Marshall College, Huntington, W. Va.*

A recently published text on Organic Chemistry makes this statement, "The Mechanism of Oxidation of the Carbon-Hydrogen Linkage is Considered as Taking Place Through the Introduction of Oxygen *Between* Carbon and Hydrogen."

My question is: What evidence have we to support this statement? Is it not more likely that water will be removed from the alcohol molecule, thus, $\begin{array}{c}\underline{\text{H O-H}}\\ \text{H-C-C-H}\\ \text{H H}\end{array}$, leaving the radical $\begin{array}{c}\text{H-C-C-H}\\ \text{H H}\end{array}$, to which ogygen may now attach directly, with a tautomeric rearrangement of the molecule to form $\begin{array}{c}\text{H O}\\ \text{H-C-C-H}\\ \text{H}\end{array}$?

I am asking if anyone has any direct experimental evidence as to the mechanism of this reaction?

CHEMISTRY TEST FROM FRANCE

607. *Submitted by M. Ginat, professeur de physique au Lycée du Havre (France).*

"I enclose in this letter some tests in physics, chemistry and mathematics which show you how great an interest we take in your pedagogical researches. They were tried out at the Lycée du Havre in October, 1930."

Chemistry Test 1

1. What elements enter into the composition of chloride of sodium?
2. What do you get when you heat a piece of crayon (chalk)?
3. What happens when you pour an acid on calcium carbonate?
4. What do you observe when you heat sea salt in a test tube with sulphuric acid?
5. What should be produced when sulphuric acid is poured on plaster?
6. A chemist wishes to prepare "gaz carbonique." He stirs some sulphuric acid with pieces of chalk placed in water. After a time the reaction ceases in spite of repeated addition of acid. Why?
7. How should the above procedure be modified to obtain a good liberation of carbon dioxide?
8. Complete the reaction:
$$CO_3\,Na_2+Ca(OH)_2=$$
9. We wish to prepare iron by thermit (aluminothermie). How much should be obtained from 54 grams of aluminum? (Fe=56; O=16; Al=27).
10. A test tube contains a solution of hydrochloric acid and aluminum chloride. A piece of soda is added. Nothing happens. A second piece gives a white precipitate which dissolves on shaking the tube. Explain the reactions which take place.

TESTS IN BIOLOGY

598. *Submitted by A. H. Bryan, Baltimore City College, Baltimore, Md.*

In SCHOOL SCIENCE AND MATHEMATICS, April, 1932, pp. 428-430, we published a description of "a complete set of achievement tests, true and false tests, and general review examinations." *Achievement Test 2* was published on page 429.

A number of requests have come in asking for further publication. Accordingly you will find Test 7 below.

Please refer to pp. 428-430, April, 1932, and let us know what else you would like to see.

True or False Test No. 7—Biology—Bryan

1. Environment is an important factor in plant growth.
2. The node is part of the root.
3. Stems act as organs of storage.
4. Synthesis of nitrogenous foods takes place in the stem.
5. The branching of an oak is excurrent.
6. Shrubs are woody plants having a single main stem.
7. Transpiration means breathing.
8. A biennial completes its life cycle in two years.
9. Protoplasm consists of woody matter, carbon dioxide, and a small quantity of sulphur.
10. Plasmodesma is part of the cell wall.
11. Chloroplasts are colorless plastids.
12. The nuclear membrane surrounds the protoplast.
13. Schleiden and Schwann are responsible for the displacement theory.

14. In absorption by the plant cell the cell sap is always less concentrated than the solution outside the cell.
15. Photosynthesis will go on without sunlight.
16. Meristematic tissue is always found near a node.
17. The plumule is the origin of the root.
18. The hemlock belongs to the Gymnospermae.
19. The sapwood is found near the center of the stem.
20. The wood rays consist of hard wood.
21. Nutritive matter passes up the xylem.
22. Chlorophyll is found in the palisade cells of the leaf.
23. The stomates are found in the lower epidermis.
24. Three or four stomates are found in each leaf.
25. The petals of a flower collectively are called the corrolla.

PICK-UP (ACCELERATION) OF AN AUTOMOBILE

608. *A problem from College Entrance Examination Board Physics, June, 1930.*

(a) How could you find the "pick-up" or acceleration of an automobile which has a speedometer?

(b) In what units would your answer be expressed?

(c) Compare the distances required for stopping an automobile going at a speed of 20 miles per hour and 40 miles per hour, assuming the same braking-force applied in each case. Show your reasoning.

IMAGINATION STIMULATOR

600. To stimulate the imagination, ask yourself this question and try to answer it: *What scientific achievement would be worth the sustained effort of the human race for a thousand years and the expenditure of uncounted millions of dollars to accomplish?*

A THOUSAND YEARS HENCE

A few suggestions by J. C. Packard, Brookline, Mass.

1. The invention of a process for the nourishment of animals, including man, that will not require the use of such enormous quantities of animal and vegetable food as are daily consumed at present.

It has been shown that the growth and development of many kinds of plants can be greatly stimulated by the direct use of electricity. Nitrogen is already being separated from the air, in large quantities, and manufactured into an artificial fertilizer for use on the farm. Concentrated food, in the form of tablets, was served out to the soldiers of several nations, in the World War, as rations for an emergency. Synthetic foods are next in line with the chemist.

Would such an achievement be likely to prove a curse or a blessing?

2. An enlargement of the field of telepathy, or mind-reading, to such an extent as to cover the human race, enabling us to do away with the typewriter, the printing press and the telephone.

There are reputed instances of clairvoyants who were able to read the mind of a given person at a great distance and to report events that were happening a thousand miles away without the aid of any mechanical means of communication. The sub-conscious mind is known to possess strange powers of *apprehension* that are but little understood at present. The space-filling properties of the electric field set up by the transmitter of the radio are suggestive of a possible mental field having similar properties.

Would life on this earth be distinctly better off for such an achievement?

3. The development of a technique of communication with disembodied spirits, if there be any such, so complete as to enable us to exchange views with those "on the other side" as easily and as surely

as we do now with one another, by telegraph, by telephone and by radio.

There are those who believe that Sir Oliver Lodge, Conan Doyle, Camile Flammarion, and a host of minor celebrities have already made a good beginning along this line and that we are right on the verge of great accomplishments. A scientic periodical of excellent repute, in America, is making a thorough investigation of the phenomena of spiritualism and, while frankly skeptical, is offering a large sum of money as a prize to anyone who will present satisfactory proofs of the genuineness of socalled spirit-control.

What is to be the outcome?

4. The discovery of a method of communication between the people on the earth and the inhabitants of some other celestial body, that will bring results.

A sum of money is being held in trust by a business house in Paris as an award for the individual who shall be the first to receive such a communication. Not so long ago two expert wireless operators in America "listened in" all night over miles of wire set apart as an aerial, for the express purpose of catching a message from Mars, if by chance any were being sent. Strange noises, whose origin appeared to be outside the vicinity of the earth, have been reported, from time to time, by wireless experts, both in this country and in Europe. Were they signals, or magnetic waves from the sun?

The telescope has revealed the physical characteristics of the universe. Is there no way of discovering its mental contest as well?

5. The cure of old age.

Ever since DeSoto led his famous expedition to the Mississippi in 1539, men have been hunting, secretly or in the open, for the fountain of perpetual youth. The causes of old age are fairly well known and much has been done along lines tending to the increase of vitality and the prolongation of youth. The average age of civilized man has been increased by at least fifteen years within a comparatively short time, and there are those who claim that old age is a matter of the mind and not of the body.

Can the average age of man be made to be commensurate with that of the big trees of California—a thousand years at least?

Would such an achievement be a blessing or a curse, to civilization? To the individual?

6. Proof of the existence of a Supreme Being to the satisfaction of the hard-headed scientist and by methods that are familiar in other fields of human activity.

The dispute between the fundamentalist and the evolutionist, between the materialist and the idealist, between the mystic and the man of science, is nearing an acute stage again. The conceit of man over his "vast accomplishments," his "mastery of the forces of nature," his "discovery of the origin of things" and of the "order of events in the development of the universe" from the electron to the nebula, has been offset to some extent by his discovery also of the immensity of the cosmic plan and the apparent "urge" toward an intelligent if not toward a spiritual end. The doings of the spiritualists, the "miracles" of healing reported in ever increasing numbers from the churches of all denominations and the near collapse of civilization itself because of disrespect for the moral law has set men to thinking as never before.

Is it possible to demonstrate God by so-called scientific methods or must we continue to rely upon faith as in by-gone ages?

How would you answer the original question?

EXAMINATION PAPERS

Please send copies of any recent examinations or tests to the *Editor*. Other teachers are interested.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON,
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS OF PROBLEMS

Editor.—Persons sending in solutions should read carefully the instructions about the form of the solutions and the ink-drawn figures. Many times, a good solution is received, but poorly arranged and no India-ink figure given.

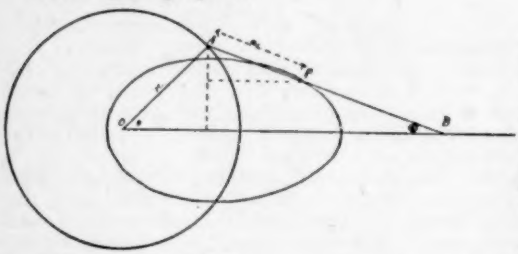
LATE SOLUTIONS

1206. *Betty Collins, Rockford, Ill.*
1210. *Leo A. Aroian, Fort Collins, Colo.*
1211. *W. E. Buker, Leetsdale, Pa.*
1216. *Everett E. Cook, University, Miss.*

1208. *Proposed by W. E. Buker, Leetsdale, Pa.*

A straight rigid rod of length k moves so that one end describes a circle, while the other end oscillates back and forth along a straight line which, if prolonged, would pass through the center of the circle. Find the locus of a point P on the rod.

Solved by the proposer.



Let AB be the rod. Let the point P be located at a distance a from A. Let $\llcorner AOB = \theta$; $\llcorner ABO = \phi$; $r =$ radius of circle.

We use rectangular coordinates with O at the origin and OB on the x axis.

Then, $x = r\cos\theta + a\cos\phi$ (1)

$y = r\sin\theta - a\sin\phi$ (2)

$r\sin\theta = k\sin\phi$ (3)

From (3), $\sin\theta = \frac{k}{r}\sin\phi$; $\cos\theta = \sqrt{\frac{r^2 - k^2\sin^2\phi}{r^2}}$

Hence, substituting these values in (1) and (2), we have

$$x = \sqrt{r^2 - k^2\sin^2\phi} + a\cos\phi \quad (4)$$

$$y = k\sin\phi - a\sin\phi \quad (5)$$

From (5), $\sin\phi = \frac{y}{k-a}$; $\cos\phi = \frac{k}{k-a}\sqrt{(k-a)^2 - y^2}$

Substituting in (4), we get the equation of the desired curve in rectangular coordinates.

$$x = \frac{1}{k-a}\sqrt{r^2(k-a)^2 - k^2y^2} + \frac{a}{k-a}\sqrt{(k-a)^2 - y^2}.$$

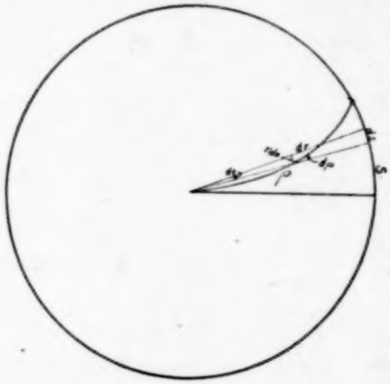
This, in general, is an oval shaped curve; if $r = k$, an ellipse; if $a = 0$, a circle; if $a = k$, a straight line.

Also solved by Leo Aroian, Fort Collins, Colo.

1217. *Proposed by P. H. Nygaard, Spokane, Wash.*

A rabbit is running at a constant speed of 30 feet per second. Along the circumference of a circle whose radius is 50 feet. A dog starts at the center of the circle and runs directly toward the rabbit at a constant speed of 60 feet per second. Find the time required for the dog to catch the rabbit.

Solved by Ralph Newman, Clarksville, Ark.



Let t = the required time
s = distance run by rabbit
$\rho = 2s$ = distance run by the dog

From the figure we observe

(1) $ds = 50\ d\theta$

(2) $d\rho = \sqrt{(dr)^2 + r^2(d\theta)^2} = 100\ d\theta$

(3) Hence $d\theta = \dfrac{dr}{\sqrt{(100)^2 - r^2}}$

(4) By substitution in (2) $d\rho = \dfrac{100\ dr}{\sqrt{(100^2) - r^2}}$

(5) $\rho = 100 \displaystyle\int_0^{50} \frac{dr}{\sqrt{(100)^2 - r^2}}$

$= 100 \text{ arc} \sin \dfrac{50}{100}$

$= \dfrac{100\pi}{6} = 52.36$ feet

$\therefore\ t = \dfrac{\pi}{60} = \dfrac{52.36}{60} = .873$ seconds

1218. *Proposed by Albert Schwartz, Brooklyn, N. Y.*

How many sides have the polygons the number of whose diagonals is a square?

Solved by W. E. Buker, Leetsdale, Pa.

If the number of sides of a polygon is n, then the number of diagonals is $\dfrac{n(n-3)}{2}$. Hence, it is required to find integral values of n which will make $\dfrac{n(n-3)}{2}$, the square of an integer.

Let $x = \dfrac{p}{q}\, n$, p and q integers.

(1) Then $n(n-3) = \dfrac{2p^2n^2}{q^2}$. Solving for n, we obtain

(2) $n = \dfrac{3q^2}{q^2 - 2p^2}$.

We are now to determine values of p and q which make n an integer and which also make x an integer. Proceeding by trial, the following values of n are found which make the number of diagonals a square. Let N = the number of diagonals.

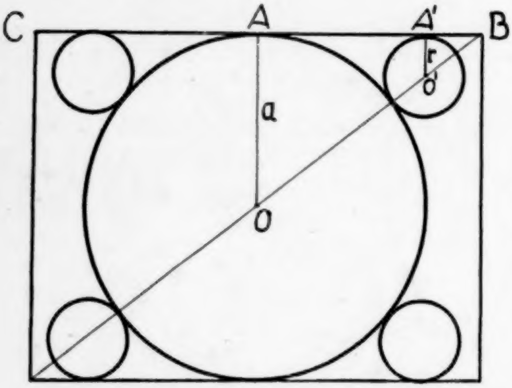
When $q = 2$ and $p = 1$, then $n = 6$ and $N = 9$
$q = 3$ and $p = 2$, then $n = 27$ and $N = 324$
$q = 10$ and $p = 7$, then $n = 150$ and $N = (105)^2$
$q = 17$ and $p = 12$, then $n = 867$ and $N = 9 \text{x} 17^2 \text{x} 144$
$q = 58$ and $p = 41$, then $n = 5046$ and $N = 3567^2$

1219. *Proposed by Guy C. Lentini, Boston, Mass.*

A sphere of radius a is placed in a cube of edge $2a$ with 8 other spheres. If each of the eight small spheres is tangent to 3 faces of the cube and externally tangent to the sphere of radius a, find the radius of a small sphere.

Solved by the proposer.

A plane containing two opposite edges of the cube will yield a rectangular section. On the section will be the traces of the great circles due to the five spheres the plane cuts. Now consider the figure.



CB = diagonal of any square face $=2a\sqrt{2}$

$OB=\sqrt{a^2+(a\sqrt{2})^2}$
$=a\sqrt{3}$

$O'B=a\sqrt{3}-(a+r)$

From similar triangles

$$\frac{A'O'}{O'B}=\frac{AO}{OB}$$

Hence

$$\frac{r}{a\sqrt{3}-(a+r)}=\frac{a}{a\sqrt{3}}$$

Which then yields the solution—

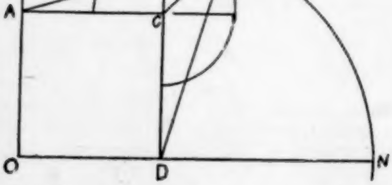
$$r=\frac{a(\sqrt{3}-1)}{\sqrt{3}+1}=.268a$$

Also solved by R. W. Hensley, Spiceland, Ind.; O. K. Defoe, Clarksville, Ark.; Harlan Reyburn, Petaluma, Calif.; Armand H. Lundquist, Moscow, Idaho; W. E. Buker, Leetsdale, Pa., and Donald Richardson, Sparta, Ill.

1220. *Proposed by J. H. Dauby.*

If a horse is tied with a rope 100 feet long to a corner of a barn 40 feet square, over how much ground can he graze?

Solved by Delbert Eggenberger, Emington, Ill.



$\angle ACB=135°$ AB = 60 ft. AC = 40 ft.

From the law of sines, angle ABC = 28° 7′ 30″

$\angle BAC=16°\ 52'\ 30''$

$\angle MAB=73°\ 7'\ 30''$

Area triangle

$$ABC=\frac{(AB\text{x}AC \sin BAC)}{2}$$

$$=\frac{40\text{x}60 \sin 16°\ 52'\ 30'}{2}$$

$=348.348$ sq. ft.

$$\text{Area sector MAB}=\frac{73.125}{360}\text{x}\pi\text{x}60^2$$

$=2297.295$ sq. ft.

Total area grazed $=(\frac{3}{4}\text{x}\pi\text{x}100^2)+2\ (348.348+2297.295)=28{,}853.286$ sq. ft.

Note: The entire area over which he grazed is not shown in the figures, but only the part which causes any difficulty.

Also solved by W. E. Batzler, Battle Creek, Mich.; Harlan Reyburn, Petaluma, Calif.; W. E. Buker, Leetsdale, Pa.; Mack Tucker, Bremen, Ind.; and Robert Head, Clarksville, Ark.

1221. *Proposed by Gunther Wuncke, Dresden, Germany.*

Find the condition which must exist between two numbers a and b, if the arithmetical, the geometrical, and the harmonical mean of them are pythagorean numbers. Solution by W. E. Buker, Leetsdale, Pa.

Between a and b, the arithmetical, geometrical and harmonical mean are $\frac{a+b}{2}$, $\sqrt{ab}$, and $\frac{2ab}{a+b}$ respectively. If these quantities are pythagorean numbers, then

$$\left(\frac{2ab}{a+b}\right)^2+(\sqrt{ab})^2=\left(\frac{a+b}{2}\right)^2$$

That is, $a^4-18a^2b^2+b^4=0$. (1)

Hence, the condition that must exist between a and b is that the[illegible] isfy equation (1).

Solving (1) for a in terms of b, we get:

$$(a^2-4ab-b^2)(a^2+4ab-b^2)=0$$

$$\therefore a=\pm b(2\pm\sqrt{5}) \qquad \text{(Four Solutions)}$$

1222. *No solution received.*

SPECIAL NOTICE TO HIGH SCHOOL STUDENTS

The Editor is pleased to make special mention as suggested in the December issue for high schools whose students as individuals or classes or clubs make noteworthy contribution to this Department. Teachers are urged to make report to the Editor when some extensive study has been made in their high school on problems submitted for solution.

In this issue we are glad to make honorable mention as follows:

1205. Raymond Freedman, South Philadelphia High School for Boys.

1220. N. Nicholson, Mathematics Club, South Philadelphia High School for Boys; Ray Barnes, Woodston (Kan.) High School; Jack Sedgwick and Clayton House, Rapid City (S. D.) High School.

1219. Charles Downer and Paul Howie, Sparta (Ill.) High School.

PROBLEMS FOR SOLUTION

1234. *Proposed by Norman Anning, University of Michigan.*

Prove that sin 2A is a rational number whenever sin A − cos A is a rational number.

1235. *Proposed by H. D. Grosman, New York City.*

Find all the real solutions of:

$$X^2-Y=2$$
$$Y^2-Z=2$$
$$Z^2-W=2$$
$$W^2-X=2$$

1236. *Proposed by L. W. Jones, Centerville, Iowa.*

Let a, b, c, d, denote four integers. Prove that the product of the difference $(b-a)$ $(c-a)$ $(d-a)$ $(d-c)$ $(d-b)$ $(c-b)$ is divisible by 12

1237. *Proposed by R. N. McGregor, Elk Grove, Calif.*

Construct a right triangle having given the sum of the base and hypotenuse and the sum of the sides about the right angle.

1238. *Proposed by Leo A. Aroian, Fort Collins, Colo.*

Find the asymptote to the Folium of Descartes: $X^3+Y^3=3AXY$

1239. *Proposed by Harry Frye, Tallahoma, Tenn.*

ADE is an equilateral triangle. BC is parallel to DE. O is a point on the segment BC.

$$BO=15,\ OC=10,\ OE+DC=100$$

Find the area of the triangle.

ESSENTIAL VOCABULARY IN ALGEBRA

By S. L. Pressey, L. C. Pressey, and F. R. Narragon,
Ohio State University, Columbus

I. Purposes and Techniques of the Investigation

Algebra, like all other school subjects, has a considerable technical vocabulary. Thus, an early study of the subject revealed a total of 382 different words.[1] Obviously, not all these words can be of equal importance, either for the study of algebra or for use as general mathematical background. It has been the purpose of this study to determine of what terms the essential "core" of algebra consisted and to develop means by which mastery of this core may be measured.

In this investigation a word has been considered "essential" (1) if it appeared often in algebra textbooks, (2) if it was regarded as necessary by experienced teachers of algebra, and (3) if it was rated by experts as being of general social value or of general use in the understanding of subjects coming later on in the average pupil's work. These three criteria have been applied consistently, and every word in the list presented later has had to measure up to the high standard.[2] In brief, the procedure has consisted, first, in making a frequency count of all words that could possibly be considered technical in six algebra texts; secondly, of submitting all words thus obtained to 42 teachers of algebra, with the request that they rate each word as "essential" (if they felt they could not teach without it) as "accessory" (if it were less vital, but still important) or as "non-essential" (if it could be dispensed with altogether, without violence to the content of the high school algebra). A consideration of the frequency results plus these ratings reduced the original list of 382 words to 86. These remaining words were next scrutinized with the greatest care by several expert secondary school teachers and by certain college professors of mathematics who were especially interested in improving the mastery of essentials by students in high school; they were also checked against

[1]Pressey, L. C. *Special Vocabularies in the Public School Subjects, No. 4.* Public School Publishing Co., Bloomington, Illinois.

[2]Aside from those few exceptions hereafter noted.

the writings of educational experts.[3] As a result of all this painstaking consideration, only 52 words emerged as essential.[4]

II. The Essential Terms

The 52 words that survived are presented below. It should be noted that they are grouped in such a way as to promote understanding.

Algebraic Numbers
symbol
*terms
quantity
*coefficient
positive
negative
*monomial
*binomial
*polynomial
algebraic
consecutive

Aggregation
parenthesis
*brackets

Proportion
proportion
ratio

Fractions
fractions
numerator
denominator
reduce
cancel
invert

Factoring
*factoring
factor
*factorable
*prime factor
*expand

Graphs
*x - axis
*y - axis
graph
*plot
*linear

Equations
equation
*degree
simple equation
*simultaneous equation
*quadratic equation
*independent
clearing of fractions
transpose
eliminate
formula
evaluate
unknown

Powers and Roots
power
exponent
root
*radical
extract
square
*cube
ascending
descending

Those terms with stars passed the two criteria of frequency and importance, but seemed of low general value; the others showed a high frequency, real importance for teaching, and value both as a basis for other subjects in the curriculum (for instance, chemistry) and as words of general everyday usefulness. For the teacher of algebra—the person presumably most interested in this work—the entire list of words may be regarded as of vital importance.

III. Practical Use of This List

Presumably the list by itself would prove useful. However, to assist the teacher still further, a test for the understanding of these terms has been prepared; thus

[3]Such as, Thorndike, E. L. *The Psychology of Algebra*, The Macmillan Company, 1923, pp. 483. Chap. II.

[4]Reference to the arithmetic and geometry lists by the same writers should be made, since some words, such as "percent," "circumference," "whole number," "pi," have been omitted from the algebra list on the ground that they belonged fundamentally to one of these other two subjects rather than to algebra.

a teacher may investigate easily the comprehension of each pupil of each technical term. A few items from the test are shown below. It is especially to be noticed that the test calls for recognition of the words in situations not dissimilar to those in which such recognition is demanded by regular class work; in no case, is a definition called for.

4. What is the coefficient of x in the equation

$12mx^2 = y^m$? $\quad 2 \quad 12m \quad 12 \quad y^m$

36. Which is a quadratic equation?

$x+2y=24 \qquad x^5-x^4-x^3-x^2-x=36$

$x^2+4x=12 \qquad x+9=2x-3$

44. Which of the following terms contains the highest power?

$\sqrt[5]{3x} \qquad 25x^2 \quad x^3 \qquad 10x^{3/5}$

One word remains to be said concerning the importance of vocabulary. To many teachers a vocabulary is "just words" and, as such, of no particular importance. It should be realized that fundamental words stand for fundamental ideas in a subject—ideas without which no mastery of subject-matter is possible. A long time ago it was pointed out that one cannot make bricks without straw; neither can a pupil learn algebra (or any other subject) without words—especially without those words that express the central core of concepts around which algebraic skills and understandings are developed.

OPERATES TO RELIEVE PROTRUDING EYES

Protruding eyes caused by goiter which sometimes persist after the goiter has been removed may themselves be corrected by a surgical operation, Dr. Howard C. Naffziger of San Francisco reported to the American Medical Association meeting recently. He reported gratifying results on six patients who had the operation on both eyes. Their eyes have receded to the normal position, their vision has been restored and there has been no recurrence thus far.

In this condition the muscles around the eyeball are swollen from three to eight times their normal size, causing abnormal pressure within the eye socket, and forcing the eyes to bulge out. In the operation, a bit of bone is removed, giving more room for the eyeball and releasing the pressure on the optic nerve by enlarging the passage through which it and the artery supplying the eye with blood enter the eye socket.—Science Service.

A STUDY OF HIGH-SCHOOL CHEMISTRY STUDENTS ELECTING CHEMISTRY IN COLLEGE

By RALPH E. DUNBAR AND ELGIE B. COACHER,

Dakota Wesleyan University, Mitchell, S. Dak.

A study was made of the high-school and college transcripts of 631 degree graduates of a college of Arts and Science to determine whether high-school seniors offering high-school credit in chemistry for college entrance showed a greater tendency to elect chemistry in college than those entering without the high-school credit in chemistry. This study covers the transcripts of all four-year graduates receiving the B. S. or B. A. degree during the period of 1917 to 1932 inclusive. The general plan of this survey was modeled somewhat after a similar survey in the state of Oklahoma (1). The tabulated findings follow:

TABLE A

Number of transcripts studied	631
Number who entered college with high-school chemistry	193
Per cent of total entering with high-school chemistry	30.58
Number who entered college without high-school chemistry	438
Per cent of total entering without high-school chemistry	69.42
Number who studied chemistry in high-school and college	113
Per cent of those who had high-school chemistry who elected college chemistry	58.54
Number who studied chemistry in college only	240
Per cent of those who did not have high-school chemistry who elected college chemistry	54.79
Per cent of those who did not have high-school chemistry who did not elect college chemistry	45.21
Number who never studied chemistry at any time	194
Per cent of total who never studied chemistry at any time	30.74
Per cent of high-schools in South Dakota offering chemistry (2)	28

An examination of the data included in Table A indicates that 438 of the 631 students or 69.42 per cent had received no chemistry during their period of high-school training. This is partly due to the fact that only about 28 per cent of the high-schools of South Dakota offer chemistry. Further, only one year of science is required for graduation by the state high-school course of study and many students often elect some other science as general science, biology, or physics.

Probably the outstanding feature of this investigation is the fact that there is a greater tendency for high-school graduates with high-school credit in chemistry to select that subject in college, than for those without the high-

school work in chemistry. However, this difference is too small to be of great significance, only 3.75 per cent. It should be remembered, however, that college chemistry is not and never has been a requirement for graduation at this institution. The only science requirement for the B. A. degree is four credits from Biology, Chemistry, Geology, Physics, Home Economics, or Mathematics, out of a total of thirty-six. Candidates for the B. S. degree select a major subject from one of the above sciences and then complete at least nine majors out of the total of thirty-six required for graduation. This would seem to be a rather liberal minimum science requirement and students have usually selected their science courses rather widely.

TABLE B—SOME COMPARISONS IN THE TWO STATES

	S. Dak.	Okla.
Probable per cent of high-schools offering chemistry	28	12
Per cent entering college with high-school chemistry	30.58	11
Per cent of those who had high-school chemistry who elected college chemistry	58.54	50
Per cent of those who did not have high-school chemistry who elected college chemistry	54.79	43.2
Per cent of total who never studied chemistry at any time	30.74	50.5

Several comparisons with the Oklahoma study are worthy of note. 11 per cent of the Oklahoma high-school seniors enter college with high-school credit in chemistry, while in South Dakota the per cent is 30.58. This difference is probably due to at least three causes. First, the difference in the general type of the two colleges surveyed. Second, to the number of high-schools offering chemistry in the two states included. Otto and Inlow (1) suggest that about 12 per cent of the Oklahoma high-schools offer chemistry, while Jensen (2) offers figures indicating that probably about 28 per cent of the South Dakota high-schools offer courses in chemistry. This would make the results proportionately about the same. Third, the two surveys cover slightly different periods. The Oklahoma survey covers the period of 1920 to about 1929 inclusive, while the South Dakota survey covers the period of 1917 to 1932 inclusive. Chemistry was a particularly popular subject during the World War and the years immediately following.

The two studies indicate that 8.54 per cent more of the students with high-school chemistry in South Dakota continue their study than in Oklahoma, and 11.59 per cent of

those without the high-school work in chemistry. And, finally, 30.74 per cent of the college graduates covered in this study never study chemistry at any time as compared to 50.5 per cent in the Oklahoma study. Both of the last two values are probably higher than is desirable, and higher than necessary with a little united effort on the part of both the high-school and college instructors in chemistry.

One of the major objectives in the teaching of high-school chemistry should be to interest the high-school students in a further study in science and chemistry in particular. This small difference of 3.75 per cent in those electing college chemistry is too small to indicate any great accomplishment on the part of high-school teachers in this respect. The authors found that the students from the largest schools who had high-school chemistry were more likely to continue the subject than those from the smallest schools. This may be due to better equipped laboratories, better trained teachers, or to a selective factor among the students.

Probably the most significant item that we as chemistry teachers need to consider is what became of that 41.46 per cent of the students who studied chemistry in high-school and did not pursue the subject further in college. Did they try it out and decide they wanted no more of it? Wasn't the subject motivated? Were they kept out by excessive requirements in other fields? And what became of the 30.74 per cent of the students who never studied chemistry in either high-school or college? We might repeat many of the same or similar questions. These and similar questions are important to the teacher of chemistry and to the individual who desires to see chemical interest and information extended to the general public. Every chemistry teacher should do all that is reasonably possible to make every high-school and college student, if not an active producer, at least an appreciative consumer in chemistry.

Literature Cited

(1) Otto and Inlow, "Do Students Who Study Chemistry in High School Elect That Subject in College?" School Science and Mathematics, XXX, 292-4 (March, 1930).

(2) Jensen, "High-School Science Survey of South Dakota," J. Chem. Ed., 4, 897-904 (July, 1927).

BOOKS RECEIVED

The Calculus by Hans H. Dalaker, Professor of Mathematics and Mechanics, University of Minnesota and Henry E. Hartig, Associate Professor of Electrical Engineering, University of Minnesota. Second edition. Cloth. Pages viii+276. 14.5x23 cm. 1932. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.25.

Jobs for the College Graduate in Science by Edward J. V. K. Menge, Director of the Department of Zoology, Marquette University. Cloth. Pages viii+175. 13.5x20 cm. 1932. The Bruce Publishing Company, 524-544 N. Milwaukee Street, Milwaukee Wisconsin. Price $2.00.

Freshman Mathematics by Hermon L. Slobin, Professor of Mathematics and Dean of the Graduate School of the University of New Hampshire and Walter E. Wilbur, Assistant Professor of Mathematics at the University of New Hampshire. Cloth. Pages xviii+438. 13.5x19.5 cm. 1932. Ray Long and Richard R. Smith, Inc., 12 East 41st Street, New York, N. Y. Price $2.60.

Principles of Chemistry by Joel H. Hildebrand, Professor of Chemistry in the University of California. Third Edition. Cloth. Pages ix+328. 13x19.5 cm. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.25.

A Course in General Chemistry including an introduction to Qualitative Analysis for use in Colleges by William C. Bray, Professor of Chemistry in the University of California and Wendell M. Latimer, Professor of Chemistry in the University of California. Revised Edition. Cloth. Pages x+159. 14x21.5 cm. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.60.

Introductory General Chemistry by Stuart R. Brinkley, Associate Professor of Chemistry, Yale University. Cloth. Pages x+565. 14x21.5 cm. 1932. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

The Story of Common Things by Louis Ehrenfeld, Curator of Chemistry in the Museum of Science and Industry, Chicago. Illustrated by Joe Richards. Cloth. Pages v+203. 12.5x19 cm. 1932. Minton, Balch and Company, 2 West 45th Street, New York. Price $2.50.

Bacteria, Yeasts, and Molds in the Home by H. W. Conn. Third Revised Edition. Revised by Harold J. Conn, Soil Bacteriologist, New York Agricultural Experiment Station. Cloth. Pages xiii+320. 12.5x18.5 cm. 1932. Ginn and Company, Number 15 Ashburton Place, Boston, Mass. Price $1.60.

Plane and Spherical Trigonometry by George N. Bauer, University of New Hampshire and W. E. Brooke, University of Minnesota. Third Revised Edition. Cloth. With tables, 394 pages, list price $2.00. Without tables, 254 pages, list price $1.72. Tables separately, 145 pages, list price $1.32. 13x19.5 cm. 1932. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass.

PAMPHLETS

General Science Laboratory Sheets by Wm. Dean Pulvermacher, Formerly in Charge of Sciences, Jr. High Schools, Acting Principal, New York Parental School, New York City and Charles H. Vosburgh, Principal, Jamaica High School, New York. 60 Experiments. 20x27.5 cm. 1932. Globe Book Company, 175 Fifth Avenue, New York, N. Y. Price 67 cents.

Persing Laboratory Chemistry Tests, Forms A and B by K. M. Persing, Department of Chemistry, Glenville High School, Cleveland, Ohio. Each Form has 4 pages. 21.5x28 cm. Price $1.00 (plus postage) per package of 25 copies of either Form A or B, one Direction

Folder, one Answer Sheet, and one class Record Sheet. Public School Publishing Company, 509-513 North East Street, Bloomington, Illinois.

High School Science Clubs by Louis A. Astell, Advisor, Junior Academy of Science and Charles W. Odell, Assistant Director, Bureau of Educational Research. Bulletin No. 60. 77 pages. 15x23 cm. 1932. Bureau of Educational Research, College of Education, University of Illinois, Urbana, Ill. Price 50 cents.

Science Reading Material for Pupils and Teachers by C. M. Pruitt. University of Alabama, University, Alabama. 27 pages. 15.5x23.5 cm. Reprinted from Science Education for October, December, 1931, February, 1932. Price 20 cents.

Report of the Visiting and Advisory Committees on the Department of Electrical Engineering. 8 pages. 14x21.5 cm. Reprinted from The Technology Review, December, 1931. Massachusetts Institute of Technology, Boston, Mass.

BOOK REVIEWS

Botany of Crop Plants, by W. W. Robbins, Professor of Botany, College of Agriculture, University of California. x+639 pp., 269 illustrations. P. Blakiston's Son and Company, 1012 Walnut St., Philadelphia. Third Edition Revised, 1931.

This book is adapted to be used as a text or reference in normal school and college classes. Part I gives the fundamental principles of botany in brief form to serve as a review for students who have had previous work in the subject. Part II contains sufficient material for a full half year course. For classes of beginning students this should be preceded by a half year of botany dealing with the fundamental principles. While the text has been written for the use of students at the college level, this new edition will prove extremely valuable, as have been the previous editions, for use as a reference in high school classes. The tendency has been more and more to stress the economic phases as an aid to the development of a botanical background of the average citizen as well as that of the person who is scientific-minded. The point of view is that of the individual who is interested in gaining information concerning the interesting and fundamental features of structure, life history, and economic phases of the common plants of the environment. Thirty-three families containing plants of economic importance are treated in as many chapters. Extended lists of references are given. For schools in which it is desired to give a course with an economic trend in the second semester of the botany course, this book cannot be too strongly recommended. Jerome Isenbarger.

Plane Geometry, by Elizabeth Buchanan Cowley, Ph.D, teacher of Mathematics, Allegheny Senior High School, Pittsburgh, Pa. Formerly Professor of Mathematics Vassar College. Pp. xii+368. Silver, Burdett and Company, New York, 1932.

This book is divided into five parts as follows: Straight-Line Figures, The Circle, Similar Polygons, Areas of Polygons, and Measurement of the Circle. The inductive method of approach is used in introducing the material and hence the student's interest in geometry is aroused. Definitions are given as needed and are also developed inductively. Each part of the book closes with a thorough review and test.

The theorems are arranged in groups with each group emphasizing a certain concept, process or principle. The exercises following each theorem are well arranged as to difficulty and are carefully selected in order to ensure mastery of the theorem. There are also sufficient exercises for accelerated pupils thus providing for individual differences. The text also meets the requirements of the College

Entrance Examination Board, the New York State Syllabus in Plane Geometry, and complies with the recommendations of the Report of the National Committee on Mathematical Requirements.

The book is well illustrated and the figures are well drawn. It is very attractive in appearance and should be favorably received by teachers of plane geometry. C. A. Stone.

Modern Junior Mathematics, by Walter W. Hart, Associate Professor of Mathematics, School of Education and Teacher of Mathematics Wisconsin High School, University of Wisconsin, Madison, Wisconsin. Book One, iii+246 pages, price 84 cents. Book Two, iii+264 pages, price 88 cents. Book Three, iii+344 pages, price $1.28. 13x19 cm. 1931. D. C. Heath and Company, New York.

This series of junior school mathematics text-books is written by an author well known in the text book field. The books are intended for junior high schools but the ninth grade or third book is also adapted for use in high schools organized on the four year plan.

The first book emphasises arithmetic, the second introduces algebra, and the third develops algebra up to and including quadratics. In all three books there is a liberal use of intuitive geometry to give meaning to the arithmetical and algebraic concepts developed. After the first book has introduced the skills and concepts of arithmetic, the second book utilizes them in their application to problems of business and the home.

Every chapter in all the books closes with a series of tests, one of which the computations mastery test is cumulative for all the arithmetical concepts previously used.

The books will develop a varied and extensive background for the pupil in geometry, algebra and arithmetic. These various subject matter fields are correlated naturally without forcing an artificial combination of algebra and geometry with arithmetic and with one another. The series will be very useful to teachers of mathematics in the junior high school. J. M. O'Rourke.

National Society for the Study of Education, Thirty-first Year-book, Part I. A Program for Teaching Science prepared by the Society's Committee, S Ralph Powers, Chairman. Pages xii+370. 15x23 cm. 1932. Public School Publishing Company, 509-513 Northeast Street, Bloomington, Illinois. Price, Cloth Bound, $2.50; Paper Covered, $1.75.

The preparation of a report on the teaching of science is a worthy undertaking which demands a great amount of time and energy even by those who have made the subject a life study. The personnel of the committee selected to prepare this report is such as to command the confidence of science teachers and school administrators everywhere. Hence the influence of the report on science education will no doubt be considerable and the responsibility for its effects correspondingly great.

The principal recommendation of the committee is for a unified program of science instruction extending from the beginning of school life through the high school. In the lower grades emphasis is to be placed on an understanding of phenomena important to everyone. As the student progresses he is to acquire ability to interpret natural phenomena and to appreciate and make use of the methods of study used by creative workers in science. Beginning of specialized study of science is recommended for the senior high school.

Such a program will certainly meet the approval of all. But the recommendations for realizing these aims are not so definite and will not meet with universal approval. In this the committee must have worked as individuals. Certainly had there been more discussion and criticism of each other's work many of the inconsistencies and fallacies would have been eliminated. Moreover, the committee was

somewhat one-sided, as all members of the committee have followed very closely the same education path. This is noticeably shown by the critical comments made by three educators from other related fields and published with the report. Each commentator approves the report except as it relates to his field. If such educators had been represented on the committee and if there had been a more critical examination of each section of the report prior to publication, a more valuable product would have resulted. As it stands it is just about as likely to be destructive of tried methods and procedures as it is to promote improvement in science teaching. Space is given here for citing a single example of a dangerous recommendation. The committee approves elimination of the double period laboratory session where class periods are fifty-five minutes in the clear. Every laboratory instructor knows this will practically destroy individual laboratory work. Some administrators have prayed for this for years. Now on approved authority their science teachers can be given two more classes each day; nothing but demonstration apparatus will be needed because there will be no time to prepare individual set-ups; pupils will look on and fill in the blanks of their note books; ingenuity and resourcefulness will not be developed because they will not be needed. This recommendation alone will, if followed, defeat the major aim of science education as set by the committee.

The report contains many similar inconsistencies which the committee could easily have discovered had time been given for critical self examination before publication. Antidotes for some of the poisons are supplied by the three critical comments published with the report. But, with all its faults, the report contains many excellent recommendations for setting up a worthy program of science education. It is already being used by various local committees in revising science curricula. May these committees have the wisdom to select the good and reject the bad. G. W. W.

General Science Laboratory Sheets, by Wm. Dean Pulvermacher, Formerly in Charge of Sciences, Junior High Schools, Acting Principal, New York Parental School, New York City and Charles H. Vosburgh, Principal, Jamaica High School, New York. 60 Experiments. 20x27.5 cm. 1932. Globe Book Company, 175 Fifth Avenue, New York, N. Y. Price 67 cents.

The aim of the authors of this manual was to develop a set of experiments and suggest a method of study and of recording results that will stimulate pupils to develop an appreciation for the achievements of science and to acquire a real interest in the subject, as well as to assimilate the important facts of elementary science. One means to this end is the use of incomplete drawings which the student must complete and properly label. Definite directions are given for manipulation and observation. Specific thought-stimulating questions requiring short answers are asked and spaces are provided for the answers. In this way little time is wasted in writing up the report, thus eliminating the drudgery and giving time for watching the experiment and thinking out its meaning. The entire report can be written in the class period under the observation of the teacher. Evidently the plan has many advantages for both pupil and teacher.

G. W. W.

The Skycraft Book, by Laura B. Harney, Teacher of Science, Washington Junior High School, Mount Vernon, New York, and Licensed Airplane Pilot. Cloth. Pages xi+338. 12.5x19 cm. 1932. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.08.

The author of this book is both a public school teacher and a licensed airplane pilot, hence knows the subject of aviation and how to present it to school boys and girls. The early history of ballooning and gliding is briefly told in the first chapter, which closes with

an account of the experiments with motor driven planes by Langley and the Wright brothers. This is followed by stories of the famous flights of recent years, and accounts of Arctic and Antarctic exploration by air. Part II consists of a discussion of types of aircraft lighter than air, and the description and history of the great dirigibles of America, England, and Germany. The third section gives many of the details of construction and operation of the various parts including a chapter on the power plant and one on instruments. Other sections of the book deal with parachutes and gliders, rules and regulations for air traffic, opportunities in aviation, and making airplane models. The book is scientifically accurate and brings the story of aviation up to the current year. It will appeal strongly to all boys and girls who have any interest in aerial navigation. G. W. W.

Medical Entomology, by William A. Riley, University of Minnesota, and Oskur A. Johannsen, Cornell University. First Edition. Cloth Pages xi+476. 1932. McGraw-Hill Book Company, Inc. New York, N. Y. Price $4.50.

The content of this book is well expressed in the subtitle—a survey of insects and allied forms which affect the health of man and animals. The material is presented in orderly fashion, and pertinent facts noted regarding the transmission, effects, and preventive measures of many common diseases. In view of the enormous body of literature dealing with this general problem, the authors are to be commended on the judicious selection of the more important cases for consideration. Especially valuable are the many keys for identification of insects of medical importance. Thirty pages are devoted to an extensive bibliography. Simple directions for the use of hydrocyanic acid gas as a method of fumigation are included in an appendix. MEDICAL ENTOMOLOGY should be equally useful to both specialized workers in parasitology and to the general student who lacks the technical background of the specialist. Its simple style and clear presentation make it readily adaptable as a reference work in biology.

J. Schuett.

Quantitative Chemical Analysis, An Introductory Course by Henry P. Talbot, late Professor of Inorganic Chemistry at the Massachusetts Institute of Technology. Seventh Edition revised and rewritten by L. F. Hamilton, Associate Professor of Analytical Chemistry, Massachusetts Institute of Technology and S. G. Simpson, Instructor in Chemistry, Massachusetts Institute of Technology. Cloth. Pages xii+253. 14x21.5 cm. 1931. Macmillan Company, 60 Fifth Avenue, New York. Price $2.50.

A seventh edition of the well known Talbots Quantitative Chemical Analysis has recently been published by the Macmillan Co., New York. The original policy of Mr. Talbot, late Professor of Inorganic Chemistry at the Massachusetts Institute of Technology, has been chiefly retained; and, in general, it has been closely adhered to in the text. Revised and rewritten by Mr. L. F. Hamilton and Mr. S. G. Simpson, both of the Massachusetts Institute of Technology, the book represents a decided improvement upon the old edition in a number of respects. Many important changes and additions have been made.

Stoichiometric principles are discussed in detail and this phase of the subject is developed gradually and in step with the related topics in the procedures and discussions of theory. In this connection, numerous illustrative problems are explained. About 225 problems with answers, are available for home assignment. These problems, most of which are new, are not given as an aggregate as heretofore, but are divided into groups with each following the corresponding discussions and illustrative examples in the text.

Of the changes in the laboratory procedure, may be mentioned the inclusion of the analysis of chloride by the indirect precipitation method, the substitution of the determination of sulphur in pyrites for the determination of sulphur in Barium Sulphate, the expansion of the procedures for the analysis of brass to cover also the analysis of bronze, and the inclusion of potentiometric titrations.

Martin Mathews.

First Year Algebra, by David A. Rothrock, Professor of Mathematics, Indiana University, and Martha Anne Whitacre, Head of the Mathematics Department in the Junior and Senior High Schools, Richmond, Indiana. Pages xi+320. 12.5x19 cm. 1932. Charles Scribner's Sons, 597 Fifth Avenue, New York. Price $1.20.

We find in this text an example of the conservative type of algebra with a decided leaning toward the functional type which is now in the process of development in the United States. The teacher who began teaching algebra forty years ago and who teaches it in the formal manipulative style of that time will find much to please him. He will find the four operations on polynomials, nests of parentheses (the nests are optional), various types of factoring and complex fractions (optional). Our old style teacher will perhaps be displeased to find that the book aims to prepare the pupil to use his algebra in geometry, physics and the sciences. Again he will be displeased to find that such modern terms as function and variable are used.

The book offers many features which are worth mentioning.

1. The formula is introduced in the first chapter and used frequently throughout the course.
2. The simple equation is introduced and emphasized in the first chapter. It is found in other chapters but is given special attention in Chapter VII.
3. Factoring is treated as a part of muitiplication and division. There is, however, a separate chapter on factoring.
4. The approximation method of finding square root is discussed.
5. There is a good chapter on ratio, proportion and variation.
6. There is an excellent chapter on numerical trigonometry.

J. M. Kinney.

Brief College Algebra, by William L. Hart, Professor of Mathematics in the University of Minnesota. Cloth. Pages xiv+369+30. 13x19.5 cm. 1932. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.96.

This book is designed for students who have had three semesters of high school algebra and by the best of those who have had only two semesters. The chapters beyond quadratics are essentially identical with those of the author's well known College Algebra, Alternate Edition, which appeared in 1931, except for the addition of logarithmic coordinates to the chapter on logarithms and a chapter on least squares. J. M. Kinney.

Freshman Mathematics, by Hermon L. Slobin and Walter E. Wilbur, the University of New Hampshire. Cloth. Pages xviii+438. 13x20 cm. 1932. Ray Long and Richard R. Smith, Inc. New York. Price $2.60.

This book presents a tandem course in college algebra, trigonometry, and analytic geometry. It is designed to cover a four-hour course in a college year. It is written in a clear, concise and straightforward style and deals only with essentials. J. M. Kinney.

The Calculus, by Hans H. Dalaker, Ph.D., Professor of Mathematics and Mechanics, University of Minnesota, and Henry E. Hartig, Associate Professor of Electrical Engineering, University of Minnesota. Cloth. Pages viii+276. 14.5x23 cm. 1932. McGraw-Hill Book Company, 330 West 42nd Street, New York. Price $2.25.

This book is a second edition. It differs from the first in that additional problems and a chapter on differential equations have been added. The first edition was reviewed in this Journal, June 1930.

J. M. Kinney.

The National Council of Teachers of Mathematics. Fifth Year Book. The Teaching of Geometry. Cloth. Pages x+206. 15x25 cm. 1930. *Sixth Year Book. Mathematics in Modern Life.* Cloth Pages ix+195. 15x23 cm. 1931. *Seventh Year Book. The Teaching of Algebra.* Cloth. Pages ix+179. 15x23 cm. 1932. Bureau of Publications, Teachers College, Columbia University, New York. Price of each volume $1.75.

The contributors to the yearbooks of the National Council of Teachers of Mathematics are well known leaders in the field of mathematics, or mathematical education. There are fourteen contributors to the Fifth Yearbook. Among these are W D. Reeve, W. R. Longley, Vera Sanford, George D. Birkhoff, Ralph Beatly, J. W. Young and William Betz. Among the contributors to the Sixth Year Book are Irving Fisher, Cassius J. Keyser, David Eugene Smith and William L. Hart.

The Seventh Yearbook deals with the teaching of algebra. In line with the recommendations of the National Committee on Requirements, special emphasis has been placed on the function concept. Three of the ten chapters deal with this phase of the subject. These chapters were written by Professor N. J. Lennes, Professor W. Lietzman and Professor E. R. Breslich. J. M. Kinney.

Living Geography Series by Ellsworth Huntington, C. Beverly Benson and Frank M. McMurry. Book I, *How Countries Differ,* 346 pp., 24 colored map plates. $1.20. Book II, *Why Countries Differ,* 506 pp., 38 colored map plates. $1.60. Index, bibliography, and statistical tables in both books. Published also in the four-book form. 1932. The Macmillan Company, New York City.

This series of books is the result of the collaboration of a noted geographer, an expert statistician, and an authority on educational methods. As might be expected from the interests of the authors, something new has been attempted. These books are neither a one-cycle nor a two-cycle series but rather two books, both covering the whole world but from different view points. In Book I the approach is largely historical, while in Book II the whole world is treated from the regional and industrial standpoint. Physical factors and particularly the influence of climate are emphasized. One wonders sometimes whether climate really can explain so much—important factor that it is.

Much new material has been introduced and there are new and refreshing view points that result from the wide experiences gained from world travel. The authors traveled over 250,000 miles, visiting every country in the world, meeting educators, business and professional people, officials and common laborers. This has resulted in a humanized and social science approach as well as a delightfully informal style. In fact, the reviewer sees this series as a valuable contribution toward strengthening the geography content of the social science program in the elementary schools.

The subject matter is organized around the unit-problem plan. Each group of units is introduced by a preview in which certain definite problems concerning these units are raised. Then in each unit the important subject matter is introduced by concise statements of distinct problems concerning the region. Thus in the North Central States unit we find the following problem statements, "How did these states come to have such valuable land?" "On what kind of a farm is our most valuable crop raised?" "Under what conditions is our most valuable crop grown?" "What is the need for cities?", etc.

While on the whole this is a notable contribution in method there are places where some geographers might not agree with the problem statements. However that would be true for any text and this series is a valuable contribution toward vitalizing geography.

The influence of Dr. McMurry is seen in the guidance on methods of study sections, and in abundant and effective teaching helps, in maps, tests, keyed references, projects, things to do, "books to read," reviews at the end of units, etc. These study aids are desirable and seem very well worked out. The numerous photographs are new and widely chosen and along with black and white maps, graphs, diagrams, etc., not only adequately illustrate the text but also introduce the child to various types of geographic illustrative material. The political, physical, and the new human use maps are grouped together at the end of each text so as to be conveniently found for reference work. This seems desirable as otherwise there would be the usual loss of time in finding them. Human use maps have never before been used in a text series. They have been used by industries, travel bureaus, etc., for some time however. These maps have some decided advantages in visualizing the distribution of products and industries and in showing the relationship between distribution and physical conditions in a way never attempted before. However, it must be pointed out that such maps cannot accurately locate production. Symbols for manufacture must be outside the city symbol—sometimes miles out—. Product symbols have to be placed away from regions of maximum production to allow room for names, boundaries, rivers, etc. These inaccuracies are unavoidable and need not detract from the value of the maps as a whole. To be appreciated these books must be examined—no review can do them justice. K. U.

Earth Features and Their Meaning. Revised Edition. By William H. Hobbs, University of Michigan. 517 pages with 27 plates and 508 illustrations; reference bibliography at the end of each chapter; appendix on mineralogy, topographic maps and geological models. 1931. The Macmillan Co., New York City. $4.50.

A revision of the well-known elementary geology text. The author believes that there is a real place for the *cultural* study of geology both within the university and among laymen interested in the origin and development of landscapes. This book is the outgrowth of a course of illustrated lectures which have been given at the University of Michigan for a number of years with the above mentioned purpose in mind. In this edition much new material has been introduced, new figures have been drawn, and two chapters on meteorology have been added.

As a textbook or library reference for prospective science teachers this book has much to offer in the way of interpreting those landscape features which all science teachers need as a cultural background—regardless of their specialty. The numerous illustrations—508 on 517 pages—will be of interest because of the way in which they aid in understanding the text material. They include line drawings, figures, landscape sketches, maps, profiles, diagrams of apparatus used by Dr. Hobbs to teach earth mechanics, and character profiles. These character profiles are line profiles of those earth features which are indicative of a type landscape. They are intended to be used in identifying types, and should prove of value for that purpose. While photographs of earth features might at first seem more desirable than sketches, the sketches are to be preferred for the reason that in a sketch the dominant key to understanding can be emphasized. Some of the sketches are too small, while others attempt too much detail. However, considered as a whole, and in the light of the author's purpose, the illustrations fulfill their mission of directing the reader's observation.

Considered as a geology for laymen it is a book which can be read intelligently by the general public. The traveler will find the dominant geological processes which are best illustrated by features in North America and Europe explained and sketched.

In Appendices A and B quick methods of determining the common minerals and short descriptions of common rocks are given. Appendix C gives directions for the preparation of topographic maps. Appendix D deals with the use of laboratory models for the study and interpretation of geological maps. K. U.

Principles of Chemistry, by Joel Hildebrand, Ph.D., Professor of Chemistry in the University of California. Third Edition. pp. ix+328. 14x20.5x3 cm. 23 figures. Cloth. 1932. $2.25. Macmillan.

This revision of an excellent text was made to bring it in line with the companion books "Reference Book of Inorganic Chemistry" by Latimer & Hildebrand and "A Course in General Chemistry" by Bray and Latimer. The new edition makes good use of the newer knowledge concerning atomic structure as applied to chemical behavior. In his preface the author meets the criticism that his plan of instruction is too difficult for the average student by replying that he believes in "deliberately exposing" the students to far more material than most of them can assimilate. He thus gives the brilliant student a decent opportunity to travel at a pace suited to him while the average student is not expected or required to get all of the material given. From a somewhat intensive study of these books the reviewer can bespeak a favorable reception for them. The material is modern, it is well taught and many a high school teacher of chemistry who has not had recent opportunity to take courses in his subject might profit largely by studying them. Frank B. Wade.

Tentative Syllabus in Biology for County High Schools. Pages 296, 1932. Tennessee State Department of Education, Nashville, Tennessee.

This syllabus for biology teachers, consisting of seventy-eight projects and two hundred and ninety-six pages, including an appendix on teaching methods and worth-while information for the biology teacher, constitutes one of the best attempts of any State Department of Education to present a functional syllabus in any of the high school sciences.

The projects outlined in the syllabus are "real" biology projects and the syllabus stresses throughout the human welfare aspects of the subject. Each project is outlined according to teaching methods, suggestions for classroom discussion, suggestions for laboratory procedure, laboratory apparatus and materials and teacher and pupil references. This syllabus is a product of the cooperative efforts of the State Department of Education, biology teachers of the State, and the State University. The syllabus is peculiarly adaptable for use in a state whose population is seventy per cent rural.

William E. Cole.

NEWS ITEM

Discards I. Q. Ratings

Use of the I. Q. as a basis for classifying pupils has been discontinued in the public schools of New Rochelle, New York, as the result of an investigation conducted by the department of psychology, research, and guidance in that city. Instead, the scores attained by pupils in achievement tests will be used, the A. R. (accomplishment ratio) replacing the I. Q.

Intelligence tests will continue to be used in unusual cases.—New Item—School Topics, Cleveland, 2-9-1932.

DEPARTMENT OF SCIENCE INSTRUCTION, N. E. A.

President, Charles Lincoln Edwards, Supervisor of Nature Study, Los Angeles City Schools, Los Angeles, California.

Secretary, W. L. Eikenberry, Head of Science Department, State Teachers College, Trenton, New Jersey.

First Session, Monday, June 27, 2:00 P. M.

SCIENCE INSTRUCTION AND SUPERVISION

"The Philosophy Underlying Nature Education," by Samuel Christian Schmucker, Professor Emeritus, State Normal School, West Chester, Pennsylvania.

"What Shall Be the Science Program for the Junior and Senior High Schools?" by Ellis Haworth, Department of Science, High Schools, Washington, D. C.

"The Cultural Value of Biology in Secondary Education," by Ralph C. Benedict, Resident Investigator, Brooklyn Botanic Garden, Brooklyn, N. Y.

"The Most Important Phase in the Pittsburgh Program of Nature Study," by John Hollinger, Department of Nature and Science Instruction, City Schools, Pittsburgh, Pa.

"High School Science," Henry T. Weed, Department of Science, Girls' Commercial High School, Brooklyn, N. Y.

Second Session, Tuesday, June 28, 2:00 P. M.

ELEMENTARY NATURE EDUCATION

Joint Session with The American Nature Study Society.

"Lessons to Be Gathered From Research Studies in Teaching Science at the Elementary School Level," by E. Laurence Palmer, Cornell University, Ithaca, N. Y.

"Children and Other Organisms of Their Environment," by Otis W. Caldwell, Director of Institute of School Experimentation, Teachers College, Columbia University, N. Y.

"The Coordinating Council On Nature Activities," by Bertha Chapman Cady, American Museum of Natural History, N. Y. C.

"Nature Education at the Brooklyn Botanic Garden," by Ellen Eddy Shaw, Curator of Elementary Instruction, Brooklyn Botanic Garden, Brooklyn, N. Y.

"Nature Education in the Los Angeles City Schools," by Charles Lincoln Edwards, Supervisor of Nature Study, Los Angeles City Schools, Los Angeles, California.

"The Development of Nature Rooms in the New York City Schools," by Van Evrie Kilpatrick, Director of Nature Garden Work, New York City Schools, N. Y.

"The Supervision of Elementary Science," by Ellis C. Persing, School of Education, Western Reserve University, Cleveland, Ohio.

Third Session, Wednesday, June 29, 2:00 P. M.

SCHOOL GARDENS

Joint Session with the School Garden Association of America. Presiding, Van Evrie Kilpatrick, Director of Nature-Garden Work, New York City Schools.

"School Gardens of Los Angeles," by Albert Marvin Shaw, Hollenbeck Junior High School, Los Angeles, California.

Demonstrations of: 1. A Model School Garden. 2. Model Nature Room. 3. Model of Institutional Cooperation in Nature Teach-

ing. Van Evrie Kilpatrick, Chairman, Ellen Eddy Shaw, Mrs. Burns, Committee.

Fourth Session, Thursday, June 30, 2:00 P. M. to 3:00 P. M.

Papers.

3:00 P. M. to 4:00 P. M.

Excursions to Seaside and New Jersey Pine Barrons. Details to be announced later.

AN APPLICATION OF CERTAIN LAWS OF PHYSICS

By Dorothy Johansen

A leaf must fall.
A steady wind has laid
Its breath upon
The greening vine.

Newton's first law of motion: Every body remains in its condition of rest or of uniform motion in a straight line except as it is compelled to change that condition by an external force applied to it.

The young leaf trembles.

Law of simple harmonic motion: Any body will vibrate with simple harmonic motion if the restoring forces brought into play by a small displacement are proportional to the displacement itself and in the opposite direction.

But the wind is strong.
Slowly the leaf begins
Its downward path.

Newton's Law of gravitation: Every particle of matter in the physical universe attracts every other particle with a force which is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

With anger chides the wind
And bears his strength
Upon its wavering side.
Swifter now it falls,
And runs before the wind.

Newton's second law of motion: The rate at which the momentum of a body changes is proportional to the impressed force causing the change and takes place in the direction of the straight line in which the force acts.

"Air, bear me up," it cries.

Frictional resistance: Friction is the resistance encountered when one solid surface slides over another. (Air resistance qualifies the solid surface of this definition.)

But fails the air as much itself
Its own resisting will is weak.

Newton's third law of motion: To every action there is an equal and opposite reaction.

The wind's caprice has caught
And held the leaf awhirl;

Then it settles quietly,
Resigned to earth again.

Centripetal force: In order that a body may continue to move at a uniform speed in a circular path, it must be constantly acted upon by a force directed toward the center of the path.

ATOM SMASHING EXPERIMENTS AT CAMBRIDGE

The experiments of Drs. J. D. Cockroft and E. T. S. Walton at Cambridge, England, are important because they demonstrate that atoms in being artificially smashed can liberate more energy than is put into the smashing process.

Although atoms have been disintegrated before, the kind of splitting discovered by Drs. Cockroft and Walton is novel. Atoms

are made up of various building units, principally protons, alpha particles, and loose electrons. The proton is the positive unit of electricity and matter and it is the heart or nucleus of the hydrogen atom. The alpha particle is the nucleus or heart of the helium atom and is made up of four protons and two electrons bound together. The electron is the negative unit of electricity or matter. Atoms are visualized as made up of hearts consisting of protons, alpha particles and electrons wrapped in a compact, heavy nuclear package, surrounded by outside electrons that can be easily removed.

The lithium atom attacked in the Cambridge experiments consists of one alpha particle and three protons with necessary negative electrons to balance the charge of the positive part. The bombardment under relatively low voltage added a proton to the combination, which then split into two alpha particles. The three protons originally in the lithium atom evidently combined with the proton to form another alpha particle.

Thus the physicists obtain a new insight into the atom.

The excess enegry, some sixteen million volts for which only six hundred volts were paid, interests them even more. If this disintegration process with a profit of energy could only be made reliable instead of requiring several million shots to record one hit, all of us would not need to worry as to the source of the future energy of the world.—Science Service.

POTASH FOR PLANTS

The World War brought home to America that our country is not fully self-sufficient in available natural resources. Potash was one of the essential raw materials for which the United States was dependent upon Germany.

Potash is just as essential to growing plants as sunshine. It is one of the triumvirate of fertilizer ingredients: Nitrates, phosphates and potash. A ton of wheat takes 12 pounds of potash out of the soil; this must be replaced as fertilizer or the soil will eventually go bankrupt.

Learning a war lesson, Uncle Sam has had his geologists explore for supplies of potash on American soil. Decades ago the U. S. Geological Survey experts recognized that the great Permian basin, 300 miles wide and twice as long, in Texas and New Mexico principally but extending into Kansas and Colorado, has earth layers similar to those in Germany and Alsace that have supplied potash to the world. Potash was first found there by the Texas state geologist, Dr. Udden, in 1912 in brine from a deep boring.

The first test hole was sunk hundreds of feet into Texas oil during the war. In 1926 Congress authorized the U. S. Geological Survey and the U. S. Bureau of Mines to investigate intensively for five years the potash deposits that lie beneath the surface. They drilled numerous wells and tested thousands of bits of rock brought up by oil-well drillers.

As a result American potash for America is assured. The geologists know where nature tucked away in Texas and New Mexico earth the valuable salts left by the evaporation of an ancient dead sea. Already one commercial company is shipping tons of potash from one New Mexico mine, enough to supply four per cent. of the nation's needs. Geology and Uncle Sam's investment for research is beginning to pay its dividends.—Science Service.